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SOIL SURVEY

Pawnee County Oklahoma

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
OKLAHOMA AGRICULTURAL EXPERIMENT STATION

HOW TO USE THE SOIL SURVEY REPORT

THIS SOIL SURVEY can be used as a guide in planning the management of farms and ranches in Pawnee County. It describes the soils; shows their location on a map; and tells what they will do if various practices are followed.

The soil map, bound in the back of this report, is a large aerial photograph of the county. On this map one can see roads, houses, streams, and other important landmarks that will help in locating each farm or ranch.

Find Your Land on the Map

To find your land on the large map, use the index to map sheets. This is a small map of the county on which numbered rectangles have been drawn to show where each sheet of the large map is located.

When you have found the map sheet for your farm or ranch, you will notice that boundaries of the soils have been outlined and that there is a symbol for each kind of soil. All areas marked with the same symbol are the same kind of soil, wherever they appear on the map.

Suppose you have found on your farm an area marked with the symbol Ca. You learn the name of the soil this symbol represents by looking at the map legend. The symbol identifies Cleora fine sandy loam.

Learn About the Soils

Cleora fine sandy loam and all the other soils mapped are described in the section, Descriptions of the Soils. Soil scientists walked over the fields and through the woodlands. They dug holes and examined surface soils and subsoils; measured slopes with a hand level; noted differences in growth of crops, weeds, brush, or trees; and, in fact, recorded all the things about the soils that they believed might affect their suitability for farming.

After they mapped and studied the soils and talked to many people about them, the scientists judged what use and management each soil should have, and then they placed it in a capability group. A capability group shows the uses that can be made of the soil and the kind and amount of management needed to protect the soil in order to obtain useful crops and other plants.

Cleora fine sandy loam is in capability unit I–1. Turn to the section, Use and Management of Soils, and read what is said about soils of unit I–1. You will want to study the table which tells you how much you can expect to harvest from Cleora fine sandy loam under two levels of management. In columns A are yields to be expected under prevailing management, and in columns B are yields to be expected under improved management.

Make a Plan

For the soils on your farm or ranch, compare your yields and farm practices with those given in this report. Look at your fields for signs of runoff and erosion. Then decide whether or not you need to change your methods. The choice, of course, must be yours. This survey will aid you in planning new methods, but it does not provide a plan of management for any single farm or ranch in the county.

If you find that you need help in planning, consult the local representative of the Soil Conservation Service or the county agricultural agent. Members of the staff of your State agricultural experiment station and others familiar with farming in your county will also be glad to help you.

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SOIL SURVEY OF PAWNEE COUNTY, OKLAHOMA

By HARRY M. GALLOWAY, Soil Conservation Service and Oklahoma Agricultural Experiment Station

Correlation by E. H. TEMPLIN and HARVEY OAKES, Soil Survey,[1] United States Department of Agriculture

United States Department of Agriculture, Soil Conservation Service, in cooperation with the Oklahoma Agricultural Experiment Station

General Nature of the Area

Pawnee County is an undulating to rolling prairie area in north-central Oklahoma. This part of the State, known in the early days as "The Strip," was opened to settlers in 1893. The settlers brought farming to an area that had been used mostly for grazing. Since then, years of almost continuous cropping have lowered fertility of the soils and started erosion, but the soils are still fairly productive. The soils and climate, now as in the past, are more favorable to raising of beef cattle than to growing of cash crops.

This survey, a cooperative contribution of the United States Department of Agriculture and the Oklahoma Agricultural Experiment Station, was made to assist farmers and ranchers in planning improved management of their cropland and range. Fieldwork was completed in 1952. Unless otherwise indicated, all statements in this report refer to conditions in the county at that time.

Location and Extent

Pawnee County, located in north-central Oklahoma (fig. 1), has a land area of 591 square miles, or 378,240

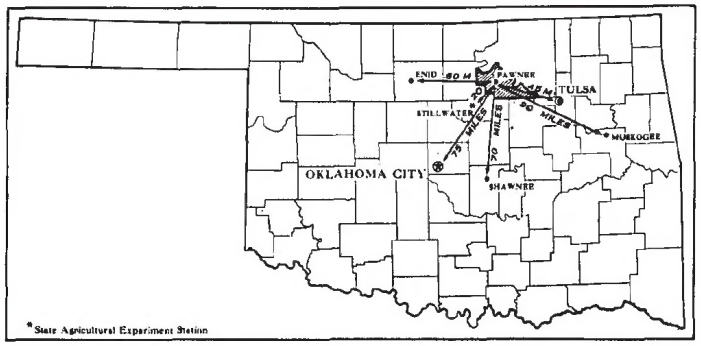

Figure 1.— **Location of Pawnee County in Oklahoma.**

acres. It is bounded on the north and east by the Arkansas River, on the west by Noble and Payne Counties, and on the south by Payne and Creek Counties. It is irregular in shape, 50 miles long and 28 miles wide at the greatest extremities. Pawnee, the county seat, is 75 miles northeast of Oklahoma City, 45 miles west of Tulsa, and 60 miles east of Enid.

Early History and Population

Pawnee County is in that part of Oklahoma formerly known as the Cherokee Outlet. For many years this area, known to oldtimers as "The Strip," had been used as grazing land. Cattlemen leased the entire strip from the Cherokee Indians. They used the lush bluestem pastures to fatten herds they brought up from Texas for sale at railheads in Kansas.

Between 1880 and 1882 (*7*),[2] the Government located many Indian tribes in Oklahoma. The Pawnee and Otoe Indians were located in what is now Pawnee County. All the tribes were given allotments of land, a specified acreage for each tribal member.

The Strip was opened to white settlers on September 16, 1893, in one of the series of "runs" to settle land that had not been set aside for the Indians. When the white settlers arrived, the Otoe and Pawnee Indians were located on scattered holdings west of a north-south line through the present site of Blackburn in Pawnee County.

The settlers could claim 160 acres. After they had lived on their land for 5 years and made some improvements, they owned their claim. Most of the early settlers came from Missouri, Kansas, Arkansas, and central Oklahoma. They brought only the simplest of tools and little livestock and provisions. They lived in tents, sod huts, and dugouts. Their first year was a dry one. Hay and pasture were scarce.

Almost immediately after the run, townsites were laid out at Pawnee, Blackburn, Cleveland, Jennings, Keystone, and Ralston. These became local trading centers. In the new farming communities, small settlements sprang up. Among these were Skedee, Masham, Lela, and Terlton. The first public school was opened in 1893, the year of the run. By 1901 there were 64 schools and several churches.

At first, there were few roads and no bridges. In 1900 the Santa Fe brought the first rail line to the county; other lines soon followed. In 1904 oil was discovered at Cleveland (*3*). Oil became an industry second only to farming, and in Pawnee County it still holds that position.

Few of the Indians turned to farming after arrival of the white settlers. Many of them gave yearly leases on their land for farming and grazing. Through the years leasing from them has been handled by the United States

[1] Fieldwork for this survey was done while Soil Survey was part of the Bureau of Plant Industry, Soils, and Agricultural Engineering. Soil Survey was transferred to the Soil Conservation Service on November 15, 1952.

[2] Italic numbers in parentheses refer to Literature cited.

Indian agency located at the Indian school in Pawnee. Some of the Indian owners or their heirs have been allowed to sell their lands, but a sizable acreage is still owned by the Indians. Most of the Indians now live in towns and villages, mainly around Pawnee. Some of them live on their holdings throughout the county (7).

The population of the county increased gradually in the early days following the run, increased rapidly after oil was discovered, reached a peak of about 20,000 in the late 1920's, and has since declined. In 1950 the population of the county was 13,616, of which about 61 percent lived in small towns. About 39 percent of the total population is in two towns—Pawnee (pop. 2,816) and Cleveland (pop. 2,464). Smaller towns are Ralston, 416; Jennings, 338; Keystone, 228; Maramec, 184; Skedee, 170; Blackburn, 135; Terlton, 122; Hallett, 120; and Quay, about 70.

Physiography, Relief, and Drainage

Pawnee County is part of the Osage Plains section of the Central Lowlands province of the United States. The county has a belt of timber known as the Cross Timbers and tracts of hilly grasslands called Bluestem hills.

The surface of the county appears to have been almost level. The uniform heights of the higher divides is evidence of this. The highest elevations range from about 1,000 to 1,060 feet, and they are well distributed throughout the county. The decrease in elevation is slight from west to east. The extreme range in elevation is from 650 feet at Keystone to 1,120 at a point in Banner Township southeast of Pawnee. The local relief is not extreme and seldom exceeds 150 feet. Most of the county is rolling, and the many escarpments and high bluffs along the rivers make parts of it hilly. The area west of Pawnee is smoother, has less pronounced ridges, and has less local relief.

The present pattern of streams is well developed, reaches every section of the county, and was formed during a single erosion cycle that followed the formation of the peneplain. Probably the cycle began in Tertiary time (5), and it is still active. The thick beds of alluvium in the stream valleys are of recent origin and are still accumulating. Minor disruption of the cycle is in places evidenced by (1) soils buried by later deposits much different from the ones from which the soils formed and by (2) the deep entrenching of stream channels.

Most of the streams flow eastward and have fairly shallow, broadly U-shaped valleys. The bottom lands of the Arkansas and Cimarron Rivers are narrow in this county because they are confined by the resistant rocks that extend south from the Flint Hills section of southern Kansas. The Arkansas River enters the county at an elevation of about 845 feet, flows for 77 miles, and leaves at an elevation of 650 feet. The river falls at a rate of 2½ feet per mile, a much greater fall than both east and west of the county.

The county is drained by two main rivers. About 450 square miles is drained by the Arkansas River through Black Bear Creek, its tributaries, and a number of shorter streams. Red Rock, Greasy, Rock, Coal, Hellroaring, Ranch, Cedar, and Bear Creeks empty directly into the river. Camp, Panther, Pepper, Crystal, Skedee, and Turkey Creeks drain first into Black Bear Creek.

Some 140 square miles of the county that lies south of Maramec and Hallett is drained by the Cimarron River through Salt, Lagoon, Kenny, and House Creeks, all of which are short local streams.

The Arkansas and Cimarron Rivers flood small parts of the bottom lands every spring. Some water flows in them the year round. The smaller streams flow intermittently and between rainy periods have water only in pools. The pools may go dry. Where these local streams cross resistant beds of limestone, they have narrow bottom lands and steeper gradients. Upstream from the channels cut in limestone, the streams may have very slight gradients and wide bottom lands.

Climate

Pawnee County has a continental climate marked by fairly low humidity and pronounced changes in temperature and precipitation (table 1). The average yearly rainfall ranges from 35 inches in the west to 38 inches in the east. During the growing season, April 5 to October 24, the yearly rainfall averages between 24 and 30 inches and is fairly well distributed.

TABLE 1.—*Temperature and precipitation at Cleveland, Pawnee County, Okla.*

[Elevation, 800 feet]

Month	Temperature [1]			Precipitation [2]			
	Average	Absolute maximum	Absolute minimum	Average	Driest year (1925)	Wettest year (1941)	Average snowfall
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	39.7	80	−7	1.64	0.82	1.26	1.6
January	37.3	81	−24	1.63	1.17	1.54	2.7
February	41.3	90	−22	1.61	.56	1.77	3.0
Winter	39.4	90	−24	4.88	2.55	4.57	7.3
March	51.5	98	−6	2.53	1.56	.67	1.0
April	60.6	96	17	4.10	2.60	5.00	[3]
May	68.6	102	26	5.36	.73	5.42	[3]
Spring	60.2	102	−6	11.99	4.89	11.09	1.0
June	77.6	108	43	4.60	3.86	6.04	0
July	82.6	114	51	2.93	5.31	2.00	0
August	82.4	114	47	3.58	1.13	6.86	0
Summer	80.8	114	43	11.11	10.30	14.90	0
September	74.2	109	31	4.24	2.80	8.73	0
October	62.5	102	11	3.35	2.17	17.81	[3]
November	50.0	89	8	2.61	1.75	1.93	.3
Fall	62.2	109	8	10.20	6.72	28.47	.3
Year	60.7	114	−24	38.18	24.46	59.03	8.6

[1] Average temperature based on a 53-year record, through 1953; highest temperature on a 52-year record, and lowest temperature, on a 50-year record, both through 1952.

[2] Average precipitation based on a 12-year record, through 1955; wettest and driest years based on a 54-year record, in the period 1900–55; snowfall, based on a 49-year record, through 1952.

[3] Trace.

Figures on average precipitation can be misleading. In summer, clear days, dry south winds, and temperatures averaging about 80° F. rapidly remove soil moisture. A maximum temperature of 114° has been recorded in both July and August. Droughts lasting 2 or 3 weeks come often, and they reduce yields. Long summer droughts damage late-planted corn; cotton, sorghums, alfalfa, and pasture are also blighted. Normally, the rainfall in fall, in winter, and early in spring is enough to replenish the subsoil moisture lost during the summer.

Much of the summer rain comes as thundershowers. The skies clear quickly after the rain, and high temperatures return. At times, cold air masses stabilize in the region north of the county and bring cloudy skies, showers, and relief from the summer heat. Hailstorms hit small areas in spring and summer.

In fall, rainfall tends to be erratic. Rains are slow and gentle, and they supply moisture that will assure fall-sown crops of a good start.

Winter precipitation is low. A little snow falls in December, January, and February; it seldom lies on the ground long. Temperatures fluctuate greatly in winter. Cold air from the north brings "northers", periods of very cold weather. The alternate flow of cold and warm air brings sharp changes in temperature. Warm air from the Gulf coast raises temperatures. A 50° temperature change is fairly common in midwinter. A minimum temperature of −24° has been recorded in January.

The winds are dominantly from the south, but during December, January, and February they come mostly from the north. Wind velocities are moderately high and are highest in March and April. Tornadoes occur occasionally in March, April, and May, but most of these affect only a small area and do limited damage.

On the average, the last killing frost in spring comes on April 5, and the first in fall, on October 24. This is an average frost-free period of 202 days. Frost has occurred as late as May 3 and as early as October 9.

Water Supply

Water for domestic use is available from wells in all parts of the county. It occurs at depths of 15 to 30 feet in the bottom lands and at depths of 25 to 40 feet in a few wells that are dug on the sandstone uplands. Most of the wells are drilled and go to depths of from 60 to 180 feet to obtain ample supplies of good water. Although some of the water contains lime and is hard, the taste is very good and it is suitable for all uses. Wells as deep as 270 feet have been drilled successfully. Below this depth, in many places, salt water is encountered.

Water for livestock and for limited irrigation is mostly supplied by artificial ponds. Pond construction has increased during the past 15 years, and ponds are now well distributed throughout the county. Some soils are not suitable for building ponds. Among these are the deep, sandy soils of the eastern part of the county. Also in this group are some of the friable soils in the mantled areas along the Arkansas River and on the sandstone uplands south of Cleveland.

In some areas water from pools in stream bottoms is used for stock. Normally this source is not dependable the year round. Springs that seep from the rocky hillsides and ravines are also locally used for stock and domestic water. All of these sources supply water of good quality. Near the oilfields some wells become polluted with salt water and the local streams are contaminated by oil waste and are also too salty for any use.

Pawnee, Cleveland, and Maramec obtain their water from reservoirs. These reservoirs are also used for recreational purposes, including boating, fishing, and duck hunting. A large dam has been authorized for construction. This dam will impound the Arkansas and Cimarron Rivers and will be used for water power and flood control. After this dam is built, some of the water will be available for irrigation. The dam will form a permanent lake extending several miles above Cleveland on the Arkansas River. It will occupy the entire valley of the Cimarron River in this county.

Vegetation

Pawnee County is a part of the great grassland area of the United States known, ecologically, as the true prairie. The normal cover for such prairie is bluestems and other medium tall grasses. The eastern third of the county is largely wooded and has grassy openings. The central third is mostly grassland with oak openings, and the western third is nearly all grassland with an invasion of oaks on the sandy ridgetops. Bottom lands throughout the county were rather thickly forested, and much hardwood growth still remains. The native forest and grasses vary greatly on different types of soils. The names and growing sites of grasses, plants, and trees common in the county are listed in the section, Management of Range and Native Meadows.

Public Facilities

Agriculturally speaking, Pawnee County rates slightly below average in comparison with other counties in the State. The acreage of crops is small, and most of the farm income depends upon the sale of livestock products. The early oil boom brought much wealth into the county, but this has been largely dissipated through inheritance. Nearly one-third of the population has moved out of the county since the 1920's.

In the past few years the country school districts have merged with those in the towns, and the rural students are taken to school by bus. A few districts have consolidated and maintain small country grade schools, but all the high schools are in the towns. High schools are located at Keystone, Cleveland, Terlton, Jennings, Hallett, Maramec, Quay, Blackburn, Ralston, and Pawnee. The standard of education conforms to State requirements.

About 12 religious faiths maintain churches in the county, all in or near the towns. A hospital is located at Pawnee. One at Hominy in Osage County serves the people of the Cleveland area. Other hospitals at Tulsa, Yale, and Stillwater in neighboring counties are available to residents of Pawnee County. Medical and dental care are available in all the larger towns.

Service clubs, garden clubs, and fraternal organizations are active in the larger towns. Women's homemaker groups are organized in all sections of the county by the Extension Service of the Oklahoma State University at Stillwater. The University also furnishes the services of a county agent and a 4–H Club advisor. Farmers have organized a soil conservation district and receive

help in this program from the Soil Conservation Service and the Agricultural Stabilization and Conservation Committee.

Now that the rural schools and churches have moved to the towns, the centers of farm social and cultural life have moved too. Improved roads that serve nearly all the county have also aided this urbanization. The roads are passable except for some periods late in winter and in spring, when travel may be difficult.

Industries

Since early in 1900 oil and gas production has been second only to agriculture as an industry in the county. The first well came in on the Lowery farm near Cleveland in 1904. Rapid development of the fields at Cleveland, Jennings, and Maramec brought a boom to the county. Oil workers flocked in from neighboring oil-producing States.

Nearly all the major oil companies now operate wells in the county. Most of the oil goes to refineries in the area. Four major pipelines pass through the eastern end of the county and serve large refineries to the north and east. Since 1923 a refinery at Cleveland has produced gasoline and other products. Some of the products are shipped north by pipeline, but most of them are marketed in the State.

The oil business declined sharply during the depression of the 1930's because of the lowered production of the wells and the low prices for oil. As materials again became available after World War II, new drilling began and still continues. New production methods and higher prices for oil have made it practical to open up old fields once thought to be exhausted. A few new fields are being tested in the county with some success. Oil production in the county averaged 155,000 barrels a month in the period from June 1, 1951 to May 31, 1952.

Several small sand plants remove the large deposits of sand and the smaller deposits of gravel from the bed of the Arkansas River. Much of this is shipped to the larger cities. Some is used to surface county roads. Good-quality limestone is located in several places. At one time two quarries produced railroad ballast, but they no longer operate. When roads are under construction, some limestone is dug from local pits.

Cotton gins and a small creamery are located at Pawnee, and one gin is in Ralston. Several small elevators at Pawnee and Ralston furnish facilities for storing grain, grinding feed, and cleaning seed.

Transportation and Markets

The Atchison, Topeka and Santa Fe Railway operates a freight line from north to south that serves Ralston, Skedee, Maramec, and Quay and connects to Cushing and Shawnee. A branch of this line goes to Pawnee. The St. Louis-San Francisco Railway (Frisco Lines) runs from Tulsa to Enid and furnishes daily passenger and freight service to Keystone, Terlton, Hallett, Pawnee, and Lela. The Missouri–Kansas–Texas Lines from Kansas City to Oklahoma City runs through Cleveland, Hallett, and Jennings.

United States Highway No. 64 crosses the county from east to west and goes through Keystone, Cleveland, Pawnee, and Lela. Buses travel this route daily and connect with buses to Pawhuska and Ponca City. State Highway No. 99 crosses the southeastern corner of the county. It connects points in southern Kansas with Seminole and Ada and serves Cleveland, Hallett, and Jennings. The roads mentioned are concrete. Oklahoma Highway No. 18 is a blacktop road that goes through central Pawnee County and serves Ralston and Pawnee. Oklahoma Highway No. 15 is an all-weather gravel road across the northwestern part of the county. Generally the county roads are spaced to serve all farm areas, and they normally follow the section lines. In 1950, 200 farms were on hard-surfaced roads; 567 on gravel, shale or shell roads; and 596 on unimproved dirt roads.

Several truck and motor express lines serve the principal towns and make daily connections with Tulsa and Oklahoma City. Most of the livestock is hauled by trucks to markets in Tulsa and Oklahoma City. There are several local cattle-hauling companies. Elevators at Pawnee and Ralston buy much of the wheat; some from the west end of the county goes to elevators at Stillwater, Perry, and Redrock. Cotton is ginned at two mills in Pawnee and one in Ralston; cotton from the eastern part of the county goes mostly to the mills in Tulsa.

Agriculture

Because the county is mostly grassland, raising of beef cattle is dominant. In 1950, only 22 percent of the county was used as cropland. Of the cropland, 20 percent was in corn, 10 percent in prairie hay, and 14 percent in wheat. Cotton, one of the principal cash crops, was grown on 14 percent of the cropland. Oats were grown on 12 percent, and grain sorghums on 8 percent. Alfalfa for hay is grown on more than 5 percent of the cropland, and other cultivated hay crops on 4 percent. There are a number of fruit orchards and many small pecan groves.

Many farmers keep hogs and small flocks of chickens. Dairying is widely practiced, but most of the herds are small. A few farms have sheep and turkeys. In some places truck crops are grown. These, like the fruit crops, are sold in nearby towns and cities.

Most fieldwork is done late in winter or early in spring. The winters are open enough to allow land preparation any time except during the "northers." In these spells of cold weather the ground may be frozen as deep as 4 or 5 inches. Little fieldwork except cultivating and haymaking is done in midsummer, because temperatures are high and the soils are dry. Land is prepared for fall-sown crops after the occasional rains in summer or early in fall. Fall sowing normally is done from late in August through November.

Land Use and Types of Farms

Pawnee County is located in what is called a general farming area. Nearly all the commercial orchards and several dairy farms are near the markets at Tulsa. South of Cleveland there is a sandy belt used extensively for grazing, and it has very little cropland. The prairies west of this belt are used for grazing cattle and for the growing of small grains and some cotton.

In 1949 and 1954 the acreage of land in farms was reported, by use, as follows:

	1949	1954
Cropland, total	123, 525	95, 464
Cropland harvested	83, 046	69, 813
Cropland used only for pasture	24, 680	17, 228
Cropland not harvested and not pastured	15, 799	8, 423
Woodland, total	75, 461	55, 812
Woodland pastured	63, 728	49, 832
Woodland not pastured	11, 733	5, 980
Other land pastured (not cropland or woodland)	123, 036	178, 216

Because some cropland and woodland are pastured, the total land used for pasture cannot be read from the tabulation just given. The total pasture area of cropland pastured, woodland pastured, and other land pastured amounted to 211,444 acres, or 55.9 percent of the county in 1949, and 245,276 acres, or 64.8 percent in 1954.

Much of the northwestern part of the county is pastureland. Feed and small-grain crops are grown only on the most favorable land. All of the land along the river and stream bottoms is cultivated to corn, small grains, cotton, and alfalfa. Corn does well on the mantled uplands along the rivers. These areas and the bottom lands are also suitable for the raising of hogs. Beef cattle are raised in all parts of the county.

Strawberries grow well on the deep, friable soils in the eastern part of the county and on the soils of the river bottoms. Both native and hybrid pecans are grown on the farms of the bottom lands.

In the list that follows the farms of the county in 1954 are classified by major source of income. The unclassified farms are part-time, residential, or abnormal farms.

Type of farm:	Number
Livestock other than dairy or poultry	498
General farms	131
Field-crop farms other than vegetable and fruit and nut	108
Dairy	66
Poultry	45
Fruit and nut	10
Vegetable	(1)
Unclassified	485

[1] None listed for 1954; 5 farms in 1950.

As the rural population has decreased, farm labor has become scarce. The area in cropland has declined more than 25,000 acres since 1949 and now comprises only about 25 percent of the county. The number of cattle has increased by nearly 16,000 in the same period.

A decline in the number of farms and in the acreage in cropland began in the 1930's and, except for a reversal of the trend for a few years during World War II, is still going on. Now there are fewer, but larger, farms than at any other time in the history of the county. The size classes of the farms and percentage of the farms in each class were reported for 1954 as follows:

Size of farms in acres:	Percent
1 to 9	7. 0
10 to 29	4. 8
30 to 49	5. 0
50 to 69	2. 2
70 to 99	10. 0
100 to 139	6. 1
140 to 179	20. 7
180 to 219	4. 2
220 to 259	8. 4
260 to 499	20. 1
500 to 999	9. 0
1,000 and over	2. 5

The constant lowering of the rural population has resulted in loss of half the potential manpower in the past 30 years. This, in turn, has necessitated changes in the types of farming. On many farms corn, cotton, and other crops that need much handhoeing have been dropped, and small grains or feed crops have been substituted. Mechanization has partially offset the loss of labor. But now it is necessary to farm larger tracts of land in order to pay for the expensive machinery. It is for this reason that the acreages of corn and cotton are still so large. Fewer operators are farming larger acreages of these crops, and they are doing so with a minimum of handwork.

Farm Tenure

Based on the 1954 census, farm tenure, on a total of 1,296 farms in Pawnee County, is as follows:

	Number	Percent
Full owners	543	41. 9
Part owners	370	28. 6
Managers	3	. 2
Tenants	380	29. 3
Cash tenants	222	58
Share tenants	42	12
Share-cash tenants	44	11
Sharecroppers	17	5

In contrast to the tabulation just given, in 1940 there were 774 full and part owners, and 1,041, or 57 percent, of the operators were classified as tenants. In the 1940 to 1950 period there were ready markets and good prices. For these reasons the number of farm owners increased.

Among the types of tenancy practiced in the county, the cash-rental method is used the most. The tenants pay so much per acre of cropland, or so much for the use of a whole farm for a year. This is the way the leases from the Indians and from absentee-owners are handled.

In the share-tenant method, the customary lease contracts are called "third and fourth." The landlord receives one-fourth of the cotton and one-third of all other crops as his share. In the share-cash method, the tenant pays part of the rent in cash and the rest in shares of the crop. Sharecroppers are furnished machinery, stock, and seed by the landlord. In turn, they receive one-half of the crops. Many tenants operate under other schemes not classified in the census.

Farm Equipment

The following list shows the percentage of the total number of farms that had various farm equipment in 1954:

	Percent
Electricity	93. 7
Telephone	56. 2
Milking machines	5. 4
Grain combine	16. 9
Cornpickers	3. 1
Pickup hay balers	11. 0
Motortrucks	59. 2
Tractors	63. 8
Automobiles	66. 9

The figures listed are based on a sampling of 20 percent of the farms. They show that Pawnee County, like most other farming areas, is becoming more mechanized. Nearly all of the rural part of the county is electrified through the Indian Electric Cooperative, a member of the Rural Electrification Administration. More than

half the farms have telephones. Modern pickup trucks are being used for pleasure as well as business. Hence, their total has increased, while the number of automobiles has decreased.

Field and other farm equipment varies greatly with the type of farm and the crops grown. To prepare the land on wheat farms, disk plows or two- and three-bottom moldboard plows and disk or spring-tooth harrows are used along with heavy tractors. All grain is drilled, and many drills have fertilizer attachments. The larger farms often have their own combines; smaller operators hire combines during the harvest. Most corn is shucked by hand, but the use of mechanical picking machines is growing. Cotton is nearly all hand picked. Labor for the cottonfields is mostly transported daily from the towns; however, a few large growers keep help on the farm during the cotton season.

Fruit farms use the lightest equipment. Normally this includes disk plows or harrows, light drills, pressure sprayers, and flatbed wagons pulled by light- or medium-draft tractors. The grain binder is still used widely, and most of the forage sorghums and some oats are harvested with this equipment. Mowers, mostly the tractor-mounted type, are used extensively. Hay is put up with the help of pickup or stationary balers; much of this work is shared or operators are hired to do it. Dairies that have more than a few cows use electric milking machines, and many have electrically cooled storage places for the milk.

The farms appear to reflect the quality of the land on which they are located, both in construction and maintenance. In the early days nearly every quarter section had a farm. Today, farm buildings average about two to the square mile, and some sections lack buildings entirely.

An average group of farm buildings will include a frame or stone house, a medium-sized barn, an implement shed, a poultry house, and often a shed to store hay. Grain is often stored in round bins or tanks.

Crops

The acreages of principal crops in 1939, 1949, and 1954 are shown in table 2. There has been a sharp decline in acreage of oats and in sorghums raised for grain. The marked increase in acreage of alfalfa about offsets the decrease in prairie hay. The acreages in corn, cotton, and wheat have fluctuated, but no trend is apparent. Many small pear orchards planted in the early days have been abandoned, so the number of fruit trees has decreased.

Corn.—Corn is normally planted early in spring so that it can mature before dry weather sets in. It grows best on the Port, Yahola, Dale, and Brewer soils of the bottom lands and on the Norge, Teller, and Vanoss soils of the uplands. Because they produce larger yields, hybrid varieties of corn are supplanting other types formerly used. Early maturing varieties are best suited to soils of the uplands; late maturing types give the best yields on soils of the bottom lands.

In this area the fields are normally plowed in fall and worked into a seedbed during winter and early in spring. In many areas, mixed fertilizers are placed with the seed at planting time. Normally, 2 or 3 cultivations are made. Yields can be increased by applying a side dressing high in nitrogen at the time of the second cultivation. In July the crop matures and is left standing in the field to dry thoroughly; it is picked by hand, or with a mechanical picker, in the fall. Corn borers are increasing, and stalks damaged by the borers may be difficult to harvest with machinery. Nearly all corn is stored on farms and used locally.

TABLE 2.—*Acreage of principal crops and number of fruit and nut trees of bearing age*

Crop	1939	1949	1954
	Acres	*Acres*	*Acres*
Corn for all purposes	16, 781	17, 319	3, 250
Small grains threshed or combined:			
Wheat	19, 240	11, 537	16, 098
Oats	21, 892	10, 065	9, 878
Sorghum:			
Grain	6, 011	4, 756	864
Forage	2, 421	1, 669	6, 412
Alfalfa	1, 910	4, 490	8, 028
Wild hay	17, 364	14, 854	12, 387
Cotton	6, 392	11, 593	3, 633
Fruit trees:	*Number* [1]	*Number* [1]	*Number*
Apple	4, 909	7, 216	6, 262
Peach	9, 799	4, 905	2, 295
Pear	2, 384	1, 155	509
Cherry	910	544	231
Plum	2, 062	1, 116	293
Pecan trees	2, 498	4, 196	4, 137

[1] Number in the census year, or 1 year later than the crop year given at the head of the column.

A rotation including a legume greatly benefits the growth of corn. Corn is often planted after sweetclover on the uplands and after alfalfa on the bottom lands. In some places cowpeas are sown with corn. They are seeded either in alternate rows with the corn or are broadcast at the last cultivation of the corn.

Wheat.—This crop grows mostly on soils of the uplands, but smaller acreages are grown on the bottom-land soils. It is sown between September 15 and November 15. In seasons of adequate rainfall, plantings as late as December will make fair growth. October 1 is the ideal planting time for best yields of both winter pasture and grain.

In this area, vetch is often planted with wheat to furnish more high-protein winter pasture and to add nitrogen and organic matter to the soil. A rotation of wheat and sweetclover is common.

The wheat harvest begins early in June and ends early in July when the wheat-vetch mixtures are harvested. Most of the crop is handled by combines, but some is still cut with a binder and threshed in the field. Much of the crop is sold at the elevators; some is stored on the farms to be used as feed. Soil to be used for wheat again is normally plowed immediately after the harvest. After the summer rains, the soil is disked in order to have a clear, firm seedbed in the fall. Wheat is usually not planted until mid-September or later because of the hessian fly, which can damage wheat that is planted early.

Most areas to be used for wheat and vetch need phosphate applications before or at the time of seeding. Even when grown alone, wheat benefits from applications of phosphate. A topdressing of high-nitrogen fertilizer

applied early in spring can sometimes benefit wheat that does not follow a legume crop.

Oats.—In the past 10 years many farmers have changed from growing oats to growing wheat. The reasons for this have been the higher prices paid for wheat and the diminishing need of oats for horses.

Oats are grown in small acreages on nearly all the deep soils of the uplands. Normally they follow a crop of corn, cotton, or sorghum on soils that were prepared during the fall and winter. Oats normally are planted in February or early in March in order to insure maturity before dry weather sets in. Ordinarily they are ready for harvest by mid-June.

Oats are mostly harvested by combine; however, there is the risk of lodging during windy periods and from shattering at time of maturity. Because the grain must be very ripe to combine well, this shattering is a serious loss. For this reason, many farmers prefer to cut the oats with a binder, shock the bundles, and thresh after the crop has fully matured in the shock.

Experimental trials have shown that fall-sown, winter-hardy oats produce higher average yields than spring oats. Fall oats should be well suited to this area, but they are not widely used. Oats give fall and winter pasture, in addition to grain, and they form a cover to prevent soil erosion.

Cotton.—For many years cotton was the chief money crop in the county. Since World War II the amount of cotton planted has decreased steadily. This has been caused partly by insufficient soil fertility and partly by the boll weevil and other insects that can destroy a whole crop. Also, the handwork required to grow a crop is expensive; hence, large yields are necessary in order to show a profit.

Cotton needs a clean, firmly packed seedbed. The heavier soils are ordinarily plowed in fall and worked in spring before planting, which is from May 1 to 15. The sandier soils can be plowed and worked in spring, and cultivation begins as soon as the crop is up to a good stand. The plants are thinned when they reach 4 to 6 inches in height. Several sprayings are needed to control insects. Hand harvesting begins as soon as a sizable amount of cotton opens from the bolls and continues as later bolls open. Harvest normally begins late in September and continues until early in winter.

Sorghums.—Sorghums are grown mostly on soils of the uplands. They are a grain substitute for corn, and they provide forage for cattle in winter. They give dependable yields of forage, if grown on soils of the uplands, because they are resistant to heat and dry weather. Grain yields are erratic because of the drought in some years, or because of the damaging effects of the sorghum webworm. This worm infests the grain heads and prevents them from filling out. If this occurs, the crop is cut with a binder when green, and the bundles are fed to livestock.

Sorghums are planted in May after the soil is thoroughly warmed. When grown for grain, they are planted in rows. When sorghums are to be cut for forage, the seeding rate is doubled and they are planted with a drill, or broadcast, and handled as a hay crop. In most places, tall grain sorghums are headed by hand after maturity. Lately the dwarf varieties have become popular, and these can be headed with a combine. Part of the crop is cut with the row binder, and the grain is threshed. Most of the grain is stored on the farm and used locally.

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Alfalfa and other hay crops.—Alfalfa is a very demanding crop and is therefore grown on soils of the highest fertility in the county. It does well on soils of the bottom lands or the uplands. This crop is planted late in August, or as soon afterward as moisture conditions permit. It is commonly planted after a small-grain crop. The soil is tilled during the summer to give a weed-free, firm seedbed. Normally about 4 cuttings of hay are obtained, except in the first year or in very dry years, when only 2 or 3 are obtained.

Soils must have additions of lime and phosphate to insure a good stand of alfalfa and to maintain the stand for the maximum length of time. If yearly topdressings of phosphate fertilizer and manure are applied, stands of alfalfa will last up to 7 years.

Prairie hay is a major crop. Buyers from other areas come into the county at harvesttime to buy part of the crop directly from the field. The price varies greatly, depending upon the amount of pasture and the supply available elsewhere. The acreage of prairie hay cut changes from year to year. Prairie hay consists mostly of big and little bluestems cut from native grass areas. Hay is cut yearly from the same meadows, which, in most places, are fenced and kept solely for the hay crop. Cutting begins in mid-July and continues through August. In moist seasons, a second crop can be harvested from the meadows in September.

Orchards.—Orchard fruits are grown mostly on the deep, friable soils of the Dougherty, Eufaula, Teller, and Vanoss series. Some home orchards are on the soils of the prairie upland.

Because of their resistance to cold, apples are the fruit best suited to the area. Normally they are planted about 40 by 40 feet, and shorter lived plum trees are set between them. The plum trees are removed as the apple trees spread. Locally, spring and early summer apples are preferred because they mature before competition from northern growers begins. New orchards require about 8 years before they bear fruit. Yields from mature orchards may be about 10 to 15 bushels per tree. Early apples require less spraying than later ones, and damage from the codling moth is generally not so great.

Plums are second to apples in importance in the county. The trees bear about 3 years after setting and last about 15 years. Plums are susceptible to the freezes early in April and must be kept out of frost pockets. Yields of from 1 to 6 bushels per tree are possible. The fruit ripens from late in June to mid-July.

A few pears are grown, but they have little commercial value because the fruit is too hard. Many small pear orchards planted on the prairies in the early days have been abandoned.

Peaches are not grown on a commercial scale because they freeze back too often in the spring. A few apricots and sour cherries are grown.

In most areas orchards are planted on the contour; a space is left between the trees for planting to rye, vetch, or a similar cover crop. Shallow cultivations are made in spring and early in summer to work the trash and mulch into the surface soil. The fruit is sold locally or in Tulsa. In some areas, the buyers come to the orchard, pay a flat rate per bushel, and pick the crop themselves.

Soil improving crops.—Sweetclover is considered the best crop for soil improvement in the county during years of favorable moisture, and it is widely used. Because it

has deep roots and the ability to provide nitrogen, this crop is suitable for improving the medium- and heavy-textured soils (*4*). During its second year sweetclover makes good pasture early in spring, and it is cut for seed the second summer. Yields of from 200 to 500 pounds per acre of seed are frequently obtained; enough seed is left on the ground to reseed the clover.

Sweetclover is normally seeded with spring oats, but it may be overseeded in spring on wheat planted in the fall. Much lime and phosphate are needed for good growth. The clover grows slowly in spring. When the grain crop is cut during good years, the clover will grow rapidly so that, in many places, it can be grazed lightly the first fall. It begins to grow early the next spring and is ready to graze by March 15. After seed harvest, the trash remaining is usually disked thoroughly into the topsoil in preparation for the next crop.

Vetch is being used more as winter pasture and a soil-improving crop. It is normally planted with wheat, but sometimes with rye. The grain helps to hold the vetch crop up for combining. In combination with wheat or rye, the vetch makes excellent winter pasture that is high in protein. Vetch does not have the deep roots of sweetclover, but it provides large amounts of nitrogen and furnishes much trash to turn under for soil improvement. Vetch is now being used in tame pasture mixtures along with winter grasses and summer legumes. If phosphate is added, it will reseed itself annually, even though it is heavily grazed.

In moist seasons Korean lespedeza is regarded as the most palatable summer pasture plant because it is ready to graze in midsummer when the native grasses become tough. It also provides small amounts of nitrogen for the soil.

This legume begins to grow early in spring and matures early in fall. Normally the lespedeza is established on croplands by overseeding oats or other small grains early in spring. The legume comes on when the grain crop is harvested. The ability to reseed annually under adverse conditions, and under heavy grazing, makes Korean lespedeza well suited to a lespedeza-small grain rotation. The soil can be readied with disk-type implements that do not bury the seed deeply. Many farmers using an oats-lespedeza rotation report a gain in the yield of oats over yields of oats grown alone.

Lespedeza also helps to improve old, partially regrassed fields that are being returned to pasture. The fields are overseeded early in spring, and the lespedeza, once established, will persist even on soils of low fertility. However, if a little lime and sufficient phosphate are added, the legume grows well on all but the most severely eroded soils. It will continue to reseed annually unless suppressed by tall grasses.

In many places, pure stands of lespedeza are harvested for seed. Yields of 300 to 600 pounds of seed per acre are obtained in good years. In exceptional years when growth is adequate, the crop can be cut for hay; yields average 1 to 1½ tons an acre. Lespedeza provides fine-stemmed, palatable hay suitable for all classes of stock.

Sericea lespedeza, a perennial variety, is substituted for alfalfa on some soils considered too poor for that crop. This variety is tall-stemmed, grows very thickly, and has a strong root from which new growth emerges each spring. It can be mowed twice yearly for hay, or it can be mowed and grazed in combination. It is considered good for control of erosion, and stands will maintain themselves almost indefinitely. It also grows better with additions of phosphate, and with some lime, if the soil is acid.

Minor crops.—Among the minor crops in the county are watermelons, muskmelons, strawberries, and several of the bramble fruits. The melons are grown mostly on the river bottoms or on the sandy soils near the rivers. They are sold locally. Strawberries are marketed locally to be frozen or canned for winter use. They mature late in May. Some raspberries, blackberries, and boysenberries are sold locally.

A very minor crop is peanuts. They grow on the sandy soils, and the crop is sold at Bristow, in Creek County, where there is a peanut plant. A few sweetpotatoes are grown and sold locally.

Cowpeas, mungbeans, and soybeans are planted in some places late in spring for hay. Millet and sudangrass are planted for hay, or for summer pasture. Normally these crops are harvested late in September. Cowpeas can be planted with corn and turned under for green manure. At times they are seeded at the last cultivation and are used for forage when corn is hogged or grazed down.

Rye and barley are two more minor crops. Although commonly considered a weed, johnsongrass is often mowed for hay where it makes thick stands on soils of the bottom lands. It makes good-quality hay and is also good pasture when it is young and growing rapidly. It is sometimes poisonous if pastured in dry seasons when it is growing slowly.

Crop Rotation

Few farmers in the county practice strict crop rotation, but many are following soil-building programs. Because of the climate, the common cornbelt rotation that includes a grass-legume crop is not practical. Therefore, for a soil-building crop, reliance must generally be put on a legume alone. This legume crop sometimes does not do well in dry years, nor does it furnish a cover for the soil as sod crops do. For these reasons, on sloping upland soils, a rotation made up of a small grain grown with sweetclover or vetch is normally used (*4*).

Sweetclover can be sown with a small grain, and a small grain can be grown again the year after the sweetclover makes seed. In this way, sweetclover and grain are on the land the first and third years, and sweetclover alone, the second year. By seeding a sweetclover-small grain mixture on only part of a farm each year, the rest of the cropland has sweetclover that can be overseeded with wheat. In this way a stand of sweetclover is maintained, and a seed crop of sweetclover can be taken during good years. This method is popular because it increases grain yields and furnishes pasture during the fall of the year the sweetclover is seeded, in the spring of the following year, and each year thereafter.

A combination of vetch and wheat or rye is used on many farms. The vetch is pastured with the wheat, and the residues following harvest are much greater than those from wheat alone. These residues are worked into the soil. If vetch makes seed well and moisture and fertilizer are adequate, it often volunteers the next year.

An oat-lespedeza rotation is used in some places. In good years, the lespedeza furnishes summer pasture at a time the land would normally be idle. The lespedeza reseeds annually, and oats are drilled on the same land each

year. Oat yields have increased, even though lespedeza does not fix large amounts of nitrogen.

On the bottom lands where the choice of crops is wider and the chances of success with legumes are greater, crop rotations are suitable but not commonly followed. Alfalfa is normally followed by corn for 2 years, and then by small grains. On most of these soils, corn or cotton is grown almost continuously. In some places sweetclover is rotated with corn, cotton, and small grains.

Fertilizer and Lime

Most soils in this county are deficient in calcium, phosphorus, and nitrogen. The use of lime and fertilizers has increased in recent years (*9*). Finely ground limestone is used to supply calcium, which is needed to neutralize the acidity of the soils. Superphosphate and raw rock phosphate are used to supply phosphorus. Nitrogen is added to the soils by growing legumes, by applying mixed fertilizers, or by applying high-nitrogen fertilizers.

Limestone and rock phosphate are normally added to the soils before seeding a legume crop. They are applied well ahead of seeding and are worked into plowed soils by double disking, or they are spread as a topdressing on pastures and are worked into the surface by harrowing. From 1 to 2 tons of ground limestone and 400 to 700 pounds of rock phosphate are commonly used per acre. Superphosphate, which is more soluble than rock phosphate, usually is added just before planting time. If added at planting time, it is put in the drill with the seed. Superphosphate is applied at the rate of about 100 pounds per acre for small grains, and at the rate of 200 pounds an acre if stands of sweetclover, alfalfa, vetch, or lespedeza are being established, or if alfalfa is topdressed yearly.

Most of the nitrogen is added to the soil in crop residues and in organic matter supplied in other ways. The use of high-nitrogen fertilizers and mixed fertilizers is increasing. The mixed fertilizers are becoming more popular. They are used mostly as starter fertilizers for corn and cotton and for gardens and other specialized uses. The high-nitrogen fertilizers, ammonium nitrate and ammonium sulfate, for example, are being used more in side dressing corn. These fertilizers are used in small quantities, because the nitrogen in them is very soluble and is lost through leaching unless the plant roots grow fast enough to absorb the element (*8*).

Finely ground rock phosphate applied to croplands and pastures can give improvement that lasts 10 to 15 years. It is used particularly to grow alfalfa and sweetclover or to introduce lespedeza into permanent pastures consisting of grasses. In fields where rock phosphate is used under alfalfa, small applications of superphosphate are usually added yearly as a topdressing. The yearly application meets the high needs of this crop and maintains the stand. Use of superphosphate is also becoming the practice in fields where rock phosphate is used under a small grain-lespedeza rotation or a small grain-vetch rotation. A small amount of superphosphate is added in the drill with the seed, as this assures good contact between the young seedlings and the readily available phosphorus they need to get a good start. Whirlwind spreaders or agitator-type box spreaders are used in applying fertilizers to pastures and to plowed lands before seeding.

Mixed fertilizers are applied with the drill at seeding time in bands on each side of the seed row. A side dressing of nitrogen for corn is added by attachments on the cultivator. It is applied at the time of the second cultivation in rows about 12 inches from the corn plants.

The amount of fertilizer to be added varies with the type of soil. It can be increased greatly if the crops are grown on a good soil under irrigation. Because rainfall affects corn production about 8 years out of 10 in this county, early maturing hybrid corn responds better to nitrogen fertilizer than the later maturing open-pollinated varieties.

Livestock

Cattle are the dominant class of livestock, and they are kept in all sections of the county. In 1954 there were 43,084 cattle of all ages, and of this total 4,847 were milk cows. Table 3 shows the numbers of livestock on farms at stated intervals since 1930.

TABLE 3.—*Livestock of all ages on farms of Pawnee County, Okla.*

Livestock	1930	1940	1950	1954
	Number	*Number*	*Number*	*Number*
Cattle	27, 267	[1] 27, 783	35, 648	43, 084
Swine	14, 858	[2] 7, 840	13, 740	6, 468
Sheep	2, 595	[3] 4, 718	1, 914	3, 707
Horses and mules	8, 808	[1] 5, 895	2, 577	1, 001
Chickens	[1] 126, 310	[2] 97, 309	[4] 86, 828	[4] 73, 721

[1] Over 3 months old.
[2] Over 4 months old.
[3] Over 6 months old.
[4] Four months old and over.

The dominant breeds of beef cattle are Hereford, Shorthorn, Aberdeen, Angus, and some Brahma. Many farms follow the practice of breeding grade cows—mixed Hereford, Shorthorn, Jersey, and Brahma breeds—to purebred bulls. By keeping the desirable heifer calves, a better bred herd is gradually built up. Bull calves are usually grown out as steers to weights of from 500 to 800 pounds. They are marketed with the cull heifers and brood cows. Many cattlemen ship in feeders from southwestern areas in April and grass-fatten them for sale in midsummer. Some farmers are buying a few registered brood cows and a registered bull. In this way, they slowly build up a select herd while they continue with their herd of grade cows. A few herds of all-registered animals are in the county.

Cattle for dairying comprise only about one-ninth of the total of the county. The principal breeds are Jersey, Holstein, a few Guernseys, and some Milking Shorthorns. The dairy herds are distributed fairly well over the county but are mostly near the towns and villages. Milk is largely marketed whole; some cream is sold. Several grade A dairies sell milk to the larger cities in this area; much milk is used on the farms.

Hogs are kept mostly on river and creek-bottom farms or on farms where corn and grain sorghum are raised for feed. Many farmers keep a few hogs for home use and sell only a few each year. The principal breeds raised are Duroc Jersey, Poland China, and Chester White. A high grade Duroc boar is kept at Cleveland for the use of members of a farmers' Duroc association. Most hogs are marketed at weights of 180 to 220 pounds.

Of the few sheep raised, the principal breed is the Hampshire, a breed good for both mutton and fleece. One

or two herds of Angora goats were observed. These are kept either for their fleece or because they help to control brush in pastures.

Horses and mules are now kept in small numbers only. Many of the horses are riding types and are used for working cattle. Few horses are kept for steady fieldwork. There are one or two breeders of Quarterhorses and Palominos in the county.

Chicken raising has been the major poultry industry in the county, but the raising of turkeys is rapidly increasing. Most of the flocks of chickens are small and mainly of the Leghorn breed. A few larger enterprises grow birds entirely for the meat market. The Broad Breasted Bronze is the leading breed of turkeys.

Much of the feed for livestock is grown locally. It consists of prairie hay or sorghum fodder supplemented by alfalfa hay and cottonseed cake or meal to supply protein during the winter and early in spring. Hogs are fed mostly on locally grown grains, or they are pastured on alfalfa. Sheep graze in pastures with the cattle, and they are fed supplemental hay and feed in winter. The amount of money spent on feed for domestic animals varies. It depends upon the amount of feed crops raised and the severity of the winter. In 1950, 1,198 farms, or about 84 percent, reported expenditures for feed.

Most of the livestock is marketed in Oklahoma City or Tulsa. A few animals are sold at Pawnee and in neighboring towns. Good breeding horses are taken to Tulsa to be sold. Eggs are sold at local outlets, but broilers and turkeys are bought up by the larger packing firms in Tulsa and Enid.

Forests

Although about 20 percent of the area in the county is in forest, only a small fraction appears to have any present or future commercial value. The soils of the bottom lands and those of the Dougherty and Eufaula series are the only ones on which the trees can grow to a size suitable for commercial timber.

Oaks, on the upland Dougherty and Eufaula soils, grow rapidly in their early stages. They reach maturity at about 18 to 24 inches in diameter and, on the better soils, reach a height of 45 to 60 feet. On the thin, stony Darnell and Stephenville soils of the uplands blackjack and post oaks are slow growing; the trees reach a height of only 25 to 30 feet. If allowed to stand long after reaching maturity, the oaks are susceptible to heart rot. This affects the entire bole of the tree and renders it useless for lumber.

Generally, on the alluvial soils of the bottom lands the trees grow faster and taller; they mature at 30 to 36 inches in diameter. Many kinds of trees grow on these soils, and most of the commercial lumber is cut from them. Stunted oaks of the uplands are considered a nuisance because they are of little value and suppress the grass beneath them. Methods of eliminating oak growth are constantly being tried. At present the trees are bulldozed or burned off the land. Fence posts, round or split, are the main product from these oaks.

A few isolated stands of red and black oaks on Dougherty and Eufaula soils are managed as woodlots. They are not grazed so that they can reproduce naturally. Large trees are cut selectively, but the areas are not culled, and the cull trees hamper growth of the good trees. Experience proves that trees in these areas should be cut when they are from 15 to 18 inches in diameter. This would average between 75 and 90 years old. Railroad ties and dimension stock are two of the possible uses for trees of this size. A few may be suitable for lumber.

Descriptions of the Soils

The following section describes the soil series, and the single soils, or mapping units, of Pawnee County.

First, the soil series is described in detail. An important part of this description is the soil profile, a record of what the soil surveyor learned when he dug a hole in the ground and examined the various layers of soil. The profile for each series was taken at a given location within one of the mapping units belonging to that series. The profile is called "typical" because, aside from minor variations, it is the kind of profile that will be found in all of the soils of a given series.

Next, each of the mapping units, or soils, in a series is described. Because all the soils in one series are basically the same, the description for each soil is brief. Those characteristics of the soil that distinguish it from other soils of the same series or from soils of other series are emphasized. Properties that affect management of the particular soil, such as slope and erosion, are normally emphasized in describing a single soil.

The location and distribution of the mapping units, or individual soils, are shown on the soil map at the back of this report. Their approximate acreage and proportionate extent are given in table 4. For definitions of "series," "types," "phases," and other special terms used in describing soils, see the section, Soil Survey Methods and Definitions.

TABLE 4.—*Approximate acreage of soils mapped in Pawnee County, Okla.*

Soil name	Area	Extent
	Acres	*Percent*
Bates fine sandy loam, 2 to 5 percent slopes	7, 800	2. 1
Brewer silty clay loam	1, 900	. 5
Brewer-Drummond complex	500	. 1
Cleora fine sandy loam	1, 400	. 4
Dale silt loam	2, 050	. 5
Darnell soils, 3 to 8 percent slopes	25, 300	6. 7
Darnell-Talihina complex, 8 to 45 percent slopes	30, 600	8. 1
Dennis loam, 2 to 5 percent slopes	50, 700	13. 4
Dennis loam, eroded, 3 to 5 percent slopes	10, 400	2. 7
Dennis complex, 5 to 8 percent slopes	2, 800	. 7
Dennis complex, severely eroded, 3 to 8 percent slopes	2, 400	. 6
Dougherty fine sandy loam, 2 to 5 percent slopes	850	. 2
Dougherty fine sandy loam, 5 to 8 percent slopes	2, 700	. 7
Dougherty and Eufaula soils, 8 to 15 percent slopes	2, 700	. 7
Eufaula loamy fine sand, 1 to 4 percent slopes	120	(1)
Eufaula loamy fine sand, 4 to 8 percent slopes	1, 300	. 3
Kirkland silt loam, 0 to 1 percent slopes	830	. 2
Kirkland silt loam, 1 to 3 percent slopes	8, 800	2. 3
Kirkland silt loam, eroded, 1 to 3 percent slopes	440	. 1
Lela soils	1, 700	. 4
Miller clay	800	. 2
Minco soils, 2 to 5 percent slopes	430	. 1
Mixed alluvial land	11, 300	3. 0

TABLE 4.—*Approximate acreage of soils mapped in Pawnee County, Okla.*—Continued

Soil name	Area	Extent
	Acres	*Percent*
Norge fine sandy loam, 2 to 5 percent slopes	1, 850	0. 5
Norge silt loam, 2 to 5 percent slopes	14, 800	4. 0
Norge silt loam, 5 to 8 percent slopes	450	. 1
Norge soils, severely eroded, 3 to 8 percent slopes	270	. 1
Parsons complex, 1 to 3 percent slopes	4, 200	1. 1
Parsons complex, eroded, 1 to 3 percent slopes	680	. 2
Port silt loam	18, 000	4. 8
Quarries	60	(1)
Renfrow silt loam, 1 to 3 percent slopes	7, 500	2. 0
Renfrow silt loam, 3 to 5 percent slopes	19, 200	5. 1
Renfrow silt loam, eroded, 3 to 5 percent slopes	5, 000	1. 3
Renfrow soils, severely eroded, 3 to 5 percent slopes	1, 300	. 3
Sandy alluvial land	2, 900	. 8
Sogn, Talihina, and Collinsville soils, 3 to 20 percent slopes	55, 540	14. 7
Stephenville fine sandy loam, 2 to 5 percent slopes	2, 200	. 6
Summit clay loam, 3 to 5 percent slopes	1, 200	. 3
Teller soils, 2 to 5 percent slopes	7, 200	2. 0
Teller soils, 5 to 10 percent slopes	2, 200	. 6
Teller and Dougherty soils, severely gullied, 3 to 8 percent slopes	970	. 3
Vanoss silt loam, 0 to 2 percent slopes	8, 100	2. 1
Vernon and Lucien soils, 5 to 15 percent slopes	25, 600	6. 8
Yahola silt loam	5, 000	1. 3
Yahola fine sandy loam	4, 100	1. 1
Zaneis soils, 2 to 5 percent slopes	21, 400	5. 7
Zaneis soils, severely eroded, 3 to 8 percent slopes	700	. 2
	378, 240	(2) 100. 0
Water	5, 760	
Total	384, 000	

(1) Less than 0.1 percent. (2) Percentage of land.

Bates Series

In the Bates series are slightly acid, well-drained soils that have a dark, granular upper subsoil and a friable, permeable lower subsoil. The soils are moderately deep and are normally mottled with yellow or reddish brown.

This series occurs principally where the sandstone bedrock is relatively thick and fairly large areas of it are exposed. The soils have formed in material weathered from brown, noncalcareous sandstone and interbedded siltstone of Pennsylvanian age. This series has developed under the bluestem type of grass cover. It is found in the cooler part of the Reddish Prairie soil zone and is closely associated with soils of the Dennis and Collinsville series. Some areas are long and narrow and occur between Darnell soils on adjoining sandstone ridges and Dennis soils on lower foot slopes. One soil of the Bates series is mapped in this county.

Bates fine sandy loam, 2 to 5 percent slopes (Ba).—This soil occurs in the eastern two-thirds of the county. Most of it is on convex side slopes of 3 to 5 percent, but about 15 percent is on ridgetops where the slopes are milder. A few areas are on concave foot slopes below Collinsville and Talihina soils. Areas of this soil normally are small and narrow.

This soil is closely associated with Dennis soils. Narrow areas of this soil frequently occur between the Stephenville soil, which is on shallow ridges, and the Dennis soils, which are on the adjoining slopes. The Collinsville soils are also associated with this soil, but they are much shallower.

Typical profile on a slope of 4 percent gradient in an undisturbed pasture 4 miles southwest of Blackburn (SW¼NE¼ sec. 3, T. 21 N., R. 6 E.):

0 to 8 inches, dark grayish-brown (10YR 4/2; 2/2, moist) fine sandy loam; weak granular; very friable; numerous worm casts; slightly acid (pH 6.5); gradual transition to underlying layer.

8 to 20 inches, dark grayish-brown (10YR 4/2; 3/2, moist) light sandy clay loam; weak granular; friable; permeable; many pinholes; medium acid (pH 6.0); 2-inch transition to layer below.

20 to 30 inches, brown (10YR 5/2; 4/2, moist) sandy clay loam, streaked with about 10 percent of yellowish brown (10YR 5/4, moist); weak medium prismatic; weak granular; friable; moderately permeable; medium acid (pH 6.0); 3-inch transition to layer below.

30 to 44 inches, yellowish-brown (10YR 5/5; 5/4, moist) sandy clay loam with many distinct, coarse mottles of yellowish red, red, and reddish brown; stratified with sandy clay and silty clay; contains thin seams of soft, partly weathered brown and reddish-brown sandstone and sandy shale; medium acid; contains light-gray layer of silty clay shale at a depth of 44 inches.

The surface soil ranges from 8 to 12 inches in thickness and from very dark brown to brown. The surface soil is lighter colored in cultivated areas. Included with this soil are areas of Fitzhugh fine sandy loam too small to be mapped separately in this county. The areas of Fitzhugh soils can be identified by the reddish-brown color of the surface layer.

Bates fine sandy loam has moderate runoff and internal drainage. The soil absorbs water readily and holds moderate amounts for plants. The amount held depends on the thickness of the soil over bedrock. The soil receives runoff from higher lying soils during heavy rains. In places erosion is severe enough to prevent the use of farm machinery. These eroded areas occur mainly around the heads of drainageways or wherever water concentrates.

Use and management (unit IIIe–2).—About 30 percent of this soil is cultivated, mainly to cotton, grain sorghums, and small grains. Pasture and meadow consisting mainly of tall grasses cover the remaining acreage.

This soil is moderately productive for the crops commonly grown if reserves of organic matter and plant nutrients are kept high. Late crops frequently do well because the soil holds summer rainfall fairly well. Eroded areas of this soil are probably better for permanent pasture than for crops. Sweetclover, vetch, and Korean lespedeza have been used successfully as pasture or as soil-improving crops. They are normally grown in rotation with wheat or oats.

Native pasture can be kept productive by controlled grazing. A good part of the bluestem should reseed annually. Abandoned cropland can be seeded to bluestem, weeping lovegrass, or lespedeza. Seeding is best done in a trash-mulch seedbed.

Brewer Series

Soils of the Brewer series have developed under grass in reddish-brown, alkaline or weakly calcareous alluvium. They are nearly level, slightly acid soils on low terraces along the inward edges of stream flood plains. Most areas are at an elevation only slightly higher than the bottom lands. The soils have a dark-brown to nearly black, strongly granular surface soil and a dark-brown, slowly permeable subsoil. The horizons are weakly defined.

Brewer silty clay loam (Bb).—This soil occurs in nearly level tracts on the fringe of the flood plain bordering Red Rock, Black Bear, and Camp Creeks. It is at a slightly greater elevation than the Port soil of the adjoining bottom lands and generally at a lower elevation than the Vanoss soil. In places, it is hard to distinguish this soil from the adjoining areas of Kirkland soils that occur at slightly higher elevations. The Kirkland soils differ in having a compact claypan subsoil. Where this soil lies downhill from bordering Sogn and Talihina soils, its alluvial parent material is somewhat mixed with colluvium.

Typical profile from a cultivated field about 0.5 mile north of Pawnee on a slope of ¼ to ½ percent (NE¼SW¼ sec. 29, T. 22 N., R. 5 E.):

0 to 10 inches, dark-brown (8YR 4/2; 2/2, moist) clay loam; strong medium granular; friable; permeable; undisturbed part below depth of 6 inches contains many pinholes and worm casts; medium acid (pH 6.0); 1-inch transition to layer below.

10 to 26 inches, dark-brown (8YR 4/2; 2/2, moist) silty clay; compound moderate medium subangular blocky and strong coarse granular; firm to very firm; sticky and plastic when wet; slowly permeable; contains many root hairs and pinholes and a few black ferruginous pellets; neutral (pH 7.2); 4-inch transition to layer below.

26 to 46 inches, dark-brown (7.5YR 4/2; 3/2, moist) silty clay specked with brown (7.5YR 4/4, moist); compound subangular blocky and weak coarse granular; very firm; hard when dry; slowly permeable; aggregates in upper part distinctly coated with light-gray films; contains a few concretions and branchlike forms of calcium carbonate; moderately alkaline (pH 8.0) and noncalcareous; 6- to 8-inch color transition in which hue is 5YR; grades to layer below.

46 to 80 inches, reddish-brown (5YR 5/4; 4/4, moist) silty clay; compound subangular block and granular; firm; slowly permeable; contains some concretions and threads of calcium carbonate; moderately alkaline (pH 8.0) but noncalcareous.

The texture of the surface soil ranges from heavy silt loam to silty clay loam; the color, from dark grayish brown to black; and the thickness, from 6 to 14 inches. The upper subsoil ranges from very dark brown to dark grayish brown in color, from silty clay loam to silty clay in texture, and from slightly acid to neutral in reaction. The lower subsoil ranges from dark grayish brown, somewhat mottled with yellowish brown, to reddish brown mottled with yellowish red. Locally, the subsoil is calcareous. The deeper part of the substratum normally is a friable silty clay loam.

Included with this soil are areas having a somewhat similar profile that is more variable and lacks the developed upper subsoil. These are areas of Lela soils that lie slightly lower than the Brewer soils. They have a more reddish surface soil than the Brewer and are closely associated with the Port soil. The areas of Lela soils included with this soil were too small to map separately.

Brewer silty clay loam has a granular surface soil that absorbs moisture readily. The soil lies above all except the highest overflows. Even in the most nearly level areas, it is seldom damaged by water standing on the surface. The clayey subsoil holds water well and furnishes ample moisture for crop growth in years of normal rainfall. The supply of organic matter is ample.

Use and management (unit I–2).—Nearly 90 percent of this soil is cultivated. The main crops—corn, cotton, small grains, alfalfa, and grain sorghums—ordinarily are not grown in planned sequence or crop rotation. Sweetclover and vetch are used to some extent as soil-improving crops and for pasture. A few tall-grass pastures and pecan groves, most of them small, are located on irregularly shaped tracts not well suited to cultivation. The pastures support a good growth of grass and are used along with soils of the adjoining uplands.

Areas of this soil close to the base of steeply sloping soils may benefit if water is diverted on the slopes above. A few very nearly level or concave spots may be improved by digging shallow ditches to remove surface water.

Brewer-Drummond complex (Bc).—In this complex Brewer and Drummond soils are so closely associated it is not practical to map them separately. They occur on the fringes of the valley floors and normally are not very deep over underlying shale. Areas of Brewer soil comprise the larger part of this complex. Round or oval-shaped spots of Drummond soil occupy from 15 to 30 percent or more of the complex. Probably these Drummond "slick spots" were formed by water seeping through the underlying shale, evaporating, and depositing salts on the surface. It is evident that these spots were fewer and less prominent before cultivation began.

The Drummond "slick spots" grade to and merge imperceptibly with the Brewer soil. As a result, the complex has a mottled surface color of dark-brown Brewer speckled with light-brown Drummond spots. Concentric soil areas lying beyond the visibly light-colored spots of Drummond appear on the surface to be normal Brewer silty clay loam. However, closer examination reveals these areas to have a dark, blocky subsoil at depths of 6 to 8 inches. This Drummond subsoil has a strongly developed claypan resembling that in Parsons soils. A profile of the Drummond soil of the complex is given here. Brewer silty clay loam was described previously.

Representative profile of Drummond silt loam in a cultivated field of less than ½ percent gradient located on the low terrace of Camp Creek, 5 miles southeast of Pawnee (SE¼SE¼SE¼ sec. 14, T. 21 N., R. 5 E.):

0 to 5 inches, pale-brown (10YR 6.5/3; 5/3, moist) silt loam layered with very pale brown (10YR 7/3, moist); strongly platy and vesicular; very powdery when dry; slowly absorptive; mildly alkaline (pH 7.5); grades at a depth of about 1 inch into brown, weak granular silt loam, which rests abruptly on layer below.

5 to 9 inches, dark-brown (7.5YR 3/2; 2/2, moist) heavy silty clay loam; coarse blocky; very compact; very plastic when wet; slight evidence of columnar structure; grades to layer below.

9 to 18 inches, dark-brown (7.5YR 4/3; 3/3, moist) heavy silty clay loam; moderate coarse blocky; grades to layer below.

18 to 36 inches, dark-brown (7.5YR 4/3; 3/3, moist) silty clay; moderate medium subangular blocky; firm; slowly permeable; grades to layer below.

36 to 48 inches, reddish-brown (5YR 5/4; 4/4, moist) silty clay similar to layer above except in color; contains a few concretions of calcium carbonate and some black ferruginous pellets.

48 to 72 inches+, reddish-brown (5YR 5/4; 4/4, moist) silty clay; similar to above layer but somewhat more friable and permeable.

All layers below 5 inches are moderately alkaline (pH 8.0) but are noncalcareous.

In some areas the profile of the Drummond soil varies from the one described. The surface layer ranges from 3 to 7 inches in thickness and from very fine sandy loam to light clay loam in texture. The blocky upper subsoil varies from a few inches to more than 20 inches in thickness, and the substratum ranges from clay loam to clay, which locally is calcareous.

The Drummond spots are associated with Lela soils in a few places. Also, the Drummond occurs with the Port soil on the higher parts of flood plains bordering the uplands and along shallow drainageways in the bottom lands. The Drummond soil occurs in many spots among the upland soils of the county, but these areas are too small to be mapped individually. The acreage of the Brewer-Drummond complex in this county is comparatively small.

Use and management (unit IIs-1).—Less than 75 percent of this complex is cultivated. The Brewer is the more productive soil in the complex. In areas where the Drummond soil grades to the Brewer, there is a noticeable change in the quality of crop growth because the Drummond is far less productive than the Brewer. Many small areas having large amounts of Drummond soil have been retired from cultivation.

A few areas are in pasture and meadow, mostly tall grasses on the Brewer, and grama and Buffalo grasses on the Drummond. Stands are neither thick nor thrifty. Overgrazing leads to weedy pastures of short grasses or annuals such as needlegrass. Controlled grazing should be practiced so that grasses may seed themselves each year.

Corn, cotton, small grains, alfalfa, and sweetclover are the main crops on this complex. Because the Drummond surface soil puddles rapidly and crusts after land preparation and seeding, it is difficult to get good stands. Crops grow fairly well on this soil in the moist spring, but are subject to drought in summer. Therefore, corn and cotton yields are not dependable on the Drummond soil.

In places cattle are fed on the Drummond spots during winter so that the manure may improve soil tilth. A small grain-legume rotation, with only limited use of row crops, is considered best for this complex under present conditions. Some farmers prefer to grow alfalfa, which does not demand yearly cultivation.

Cleora Series

In the Cleora series are well-drained, slightly acid alluvial soils that have a dark grayish-brown, friable surface layer, a brown subsoil, and, normally, a substratum that is yellowish brown or slightly reddish brown in the deeper part. The profile is distinctly stratified. The soils are on the low, mostly narrow and dissected bottom lands in the eastern part of the county. The alluvium in which they are forming has been washed from the dark-colored prairie soils and associated forest soils of the Cross Timbers.

Because stream channels meander in the bottom lands, areas are broken into small, irregular-shaped fields, many of which are hard to cultivate. One soil of this series is mapped in the county.

Cleora fine sandy loam (Ca).—This noncalcareous, friable soil occurs on undulating bottom lands where slopes range from ½ to 1½ percent. Drainage is good. The soil absorbs water readily and easily delivers moisture to growing plants. Normally this soil lies a few feet lower in elevation than the Port soil and is subject to more frequent overflow.

Typical profile, in the Cedar Creek flood plain on the south side of Cleveland, in an area once cultivated but now in pasture (SE¼NE¼NW¼ sec. 17, T. 21 N., R. 8 E.):

0 to 18 inches, dark grayish-brown (10YR 4/2; 3.5/2, moist) fine sandy loam to light loam; weak granular; friable; slightly acid (pH 6.2); grades to the layer below.

18 to 30 inches, dark grayish-brown (10YR 4/2; 3/3, moist) fine sandy loam, weakly stratified with loam and sandy clay loam; weak granular structure; friable; slightly acid (pH 6.2); contains a few streaks of other shades of brown; indistinct transition to the layer below.

30 to 46 inches, yellowish-brown (10YR 5.5/4; 9YR 5/4, moist) fine sandy loam or loam; stratified with 1-inch layers of dark-brown and dark reddish-brown sandy clay loam; the fine sandy layers are of weak granular structure, the clay loams are moderate granular; slightly acid (pH 6.5); grades to the layer below.

46 to 80 inches +, brown (7.5YR 5/4; 4/3, moist) loam streaked with reddish brown and pinkish white; weak granular structure; very similar to the layer above; slightly acid (pH 6.5).

The texture of the surface soil varies from a light fine sandy loam to a loam. In places the underlying layers are stratified with loamy fine sand and sandy clay loam, and their color may be yellowish red, red, or strong brown. Narrow areas of this soil adjoining sandy soils of the uplands, such as the Dougherty, may have a light-brown surface soil overlying dark-brown material.

Use and management (unit I-1).—About a third of this soil is cultivated. There are a few small areas of hardwood forest, and the rest of the soil is in pasture. The main crops are corn, cotton, grain sorghums, and alfalfa, all of which yield rather low under prevailing methods. Proper use of amendments would increase yields. Alfalfa particularly needs lime and phosphate. Johnsongrass, a serious pest in cultivated fields, grows fairly well with alfalfa. During the first years after the alfalfa is seeded, the mixture makes good hay. Eventually the alfalfa dies out.

This soil is used mostly for pasture because the areas are small and irregularly shaped. Bermudagrass does well, and Korean lespedeza, or possibly some winter legume, can be seeded over the bermudagrass to form very productive pasture. Overflows do not hinder treatment of pasture in this way. Trees suitable for fence posts can be planted in many areas. Catalpa and black locust grow well on this soil.

Dale Series

The Dale soils have a well-drained, friable surface soil, a brown moderately sandy subsoil, and a more reddish, deep substratum. They have developed under grasses and scattered lowland hardwoods in alluvium later covered by windblown loess.

These soils are in the valleys of the Arkansas and Cimarron Rivers and are 6 to 10 feet higher in elevation than the lighter colored Yahola soils. In some places along the Cimarron River, the Dale soils are associated with the

sandier and less dark Minco soils. In many places the Dale soils are bordered by sloping areas of Teller, Dougherty, and Eufaula soils, all on the uplands. Only one soil of the Dale series is mapped in the county.

Dale silt loam (Da).—Areas of this soil mapped in Pawnee county exhibit a deep, dark surface soil. The widest areas of this soil are normally level, but narrow strips have slopes of as much as 2 percent, and locally the relief is slightly wavy.

This soil absorbs water readily. The subsoil retains sufficient moisture to carry crops through fairly long dry periods. This is considered the most productive soil in the county.

Representative profile in a cultivated field, on a slope of ½ percent on a wide terrace of the Arkansas River 1 mile north of Cleveland (SE¼SE¼NE¼ sec. 5, T. 21 N., R. 8 E.):

0 to 30 inches, dark grayish-brown (10YR 4/2; 3/2, moist) silt loam or heavy very fine sandy loam; weak granular structure; friable; permeable; indistinct transition to layer below.

30 to 50 inches, brown (7.5YR 5/4; 4/3, moist) silt loam or heavy very fine sandy loam; weak granular structure; friable; permeable; contains a few streaks or pockets of dark-brown material.

50 to 80 inches, yellowish-red (6YR 5/5; 4/4, moist) very fine sandy loam; weak angular breakage; weak granular structure; very friable; slight evidence of stratification in the lower part.

The entire profile is about neutral in reaction.

The surface layer varies from 18 to 30 inches in thickness and from very fine sandy loam to loam or silt loam in texture. Weak strata of loam and clay loam occur in the upper part of the substratum. The deeper part of the substratum varies from brown to yellowish red, and it is more sandy than overlying layers. In places the surface is covered with 6 to 12 inches of a light-brown sandy loam or loam that has washed down from the adjoining sandy uplands.

Mapped with this soil are a few long, narrow swales that have a clay loam surface soil. These inclusions make up less than 5 percent of any area of Dale silt loam.

Use and management (unit I–2).—About 95 percent of this soil is cultivated, and very little has been retired from use. The soil responds well to management. Yields can be increased by the use of fertilizers high in nitrogen and phosphorus. The soil is easily tilled and can be managed readily if water on slopes above is diverted and johnsongrass is controlled.

All crops common in this area do well on this soil. In order of importance, the principal crops are corn, wheat, oats, cotton, alfalfa, and sorghums. A few areas are in truck crops. High yields of corn are obtained after a stand of alfalfa is plowed under. The benefits from alfalfa seem to last for 2 crops of corn and 1 crop of a small grain. Vetch and lespedeza are also seeded with small grains, and both provide good grazing.

The few areas not cultivated are mostly small, irregular patches that support vigorous stands of tall grasses, johnsongrass, and several pecan groves. Proper application of phosphate and systematic rotation of legumes would increase the productivity of the soil.

Darnell Series

Soils of the Darnell series have developed under scrubby oak forest on noncalcareous, reddish and brownish sandstone. They are principally on the broad, convex slopes of ridges in the Cross Timbers. These are shallow soils; they have a thin surface soil darkened by organic matter and a light-colored, leached subsurface layer that lies over soft, partly weathered sandstone.

The Darnell soils are most extensive in the eastern part of the county; small areas are in the western part. Their parent materials are similar to those of Stephenville fine sandy loam, 2 to 5 percent slopes, which is of moderate depth and has a sandy clay subsoil. Darnell soils resemble the Lucien and Collinsville soils, but they have a lighter colored surface layer. Associated with the Darnell soils are the Bates and Zaneis, which are deep, friable, prairie soils.

Darnell soils, 3 to 8 percent slopes (Db).—These friable, excessively drained soils have no texture name because the texture varies so much within small areas. The largest areas of these soils are in the eastern part of the county. Few soils of other kinds are included. The extreme slope range for Darnell soils is 2 to 10 percent, the dominant range is 3 to 8 percent, and the average is 6 percent.

Typical profile 3½ miles southeast of Cleveland on a convex slope of 4 percent, under a cover of post oak and blackjack oak (NE¼NW¼NE¼ sec. 33, T. 21. N., R. 8 E.):

0 to 4 inches, brown (10YR 5/3; 3/2, moist) light fine sandy loam; weak granular structure; very friable; rapidly permeable; trees have spread network of root hairs and roots in layer; roots range up to ¼ inch in diameter; ¼-inch layer of leaves on surface, and first ½ inch of mineral soil is darker than rest of layer; 1-inch transition to layer below.

4 to 8 inches, light-brown (7.5YR 6/3; 4/3, moist) light fine sandy loam; porous but massive; very friable; rapidly permeable; upper part contains a few root hairs and is laced with a network of lateral oak roots ¼ to 1 inch in diameter; 2-inch transition to layer below.

8 to 15 inches, reddish-yellow (7.5YR 6/6; 6/8, moist) fine sandy loam streaked with reddish brown and strong brown and seamed with soft, partially weathered sandstone; at a depth of 15 inches there is a bedrock of brown, medium-hard sandstone.

The reaction of all layers in this soil is slightly acid (pH 6.0 to 6.5). The two layers nearest the surface range from 4 to 16 inches in combined thickness, and the soil is thin near the outcropping sandstone ledges. In many places transitional to the Stephenville soil there is a 2- to 6-inch layer of light sandy clay loam between the surface soil and the rock. This transitional layer is particularly evident where the slopes are smoother. The bedrock ranges from brown to reddish brown; it is more reddish in the western part of the county.

Included with these soils are small areas of Stephenville soil, and most areas contain a small percentage of Pottsville soil, which is not mapped separately in this county. These inclusions account for about 5 percent of the areas in which they occur.

A few formerly cultivated areas of Darnell soils have a splotchy light-brown and brownish-yellow color at the surface. In these places there is a thin cover of small sandstone fragments, as well as rills and gullies that have cut down to bedrock. Most of these areas were retired from cultivation because of erosion.

Darnell soils absorb water readily but store a limited amount for plants. The water passes down into the rock, and some of it moves out into springs. The soils stay

moist in spring but dry quickly in summer, especially if they have a thick cover of trees or grass. The grasses become dry and unpalatable in summer.

Use and management (unit VIs–2).—Nearly all of this soil is in oak woodland or thinly wooded pasture. A few areas once cultivated have been abandoned and now support thin stands of grass. Tall grasses, naturally present under the forest, spread and make fair pasture if the trees are removed and sprouts are controlled. Bermudagrass and weeping lovegrass have been used successfully in improved pastures.

These soils are low in fertility. Liberal application of phosphate and nitrogen is required for good growth of forage. In a few areas where the soils are deeper, small fruits and berries can be grown because they mature before the dry season.

Currently, the forests on the Darnell soils have no commercial value. The trees grow too slowly and decay too early to produce sawlogs; they are not readily treated with preservatives to increase their useful life as fence posts. Possibly they would be suitable for pulpwood, if a mill for processing were built. As they are now, the trees interfere with the growth of grass, and owners try to thin them out or kill them chemically.

Darnell-Talihina complex, 8 to 45 percent slopes (Dc).—This is a complex mixture of light-colored, shallow soils. The cover is scrubby post and blackjack oaks and hickory and a sparse growth of bluestem grasses. The parent material weathered from shale and interbedded sandstone of Pennsylvanian and Permian ages. The complex normally is about 50 percent Darnell soils, 25 percent Pottsville, and 25 percent Talihina. The proportion of these soils varies in different areas. The complex (fig. 2) occurs mainly in the eastern part of the county, but there are areas in nearly all parts.

This complex occurs mostly on steep slopes along drainageways, where bands of sandstone and shale are exposed. The result is a modified stairstep topography. The Darnell soils, overlying the resistant sandstone, form the risers of the steps; the Pottsville and Talihina, overlying the more easily weathered shale, form the treads. The Talihina soils are in the places where bluestem grasses are dominant. The Pottsville are lighter colored than the Talihina and are mainly under forest. Sandstone blocks and slabs have moved down the slopes and cover 5 to 10 percent of most areas in this complex.

The Darnell and Talihina soils are described elsewhere in this report. The Pottsville soil, not mapped separately in this county, has a cover of post oak, blackjack oak, and pignut hickory. The stand is poor. The trees are scrubby—25 to 30 feet high but only about 5 inches in diameter at breast height. Slopes range from 6 to 20 percent. Surface runoff is excessive. Drainage through the soil is very slow, and water seeps out on the side slopes.

Profile of Pottsville loam ½ mile south of Cleveland on a slope of about 8 percent under a cover of post and blackjack oaks (NW¼SW¼NW¼ sec. 16, T. 21 N., R. 8 E.):

0 to 4 inches, grayish-brown (10YR 4.5/3; 4/3, moist) loam; weak platy to weak granular structure; friable; contains numerous fine chips of weathered sandstone; many fine roots from trees in layer; medium acid (pH 5.9); grades to layer below.

4 to 13 inches, light yellowish-brown (10YR 6.5/4; 6/4, moist) clay loam finely mottled with brownish yellow (10YR 6/6, moist); weak platy to weak granular structure; contains chips of soft, brown sandstone and seams of silty shale; medium acid (pH 5.8); grades to layer below.

13 to 24 inches, yellowish-brown (10YR 5/7) silty clay marked with fine red spots and some 10 percent, by area, of brownish yellow (10YR 6/6, moist); upper part contains seams of brownish-yellow, soft, partially weathered sandstone; material in this layer is only slightly altered silty shale with seams of soft sandstone; roots penetrate along the bedding planes; medium acid.

***Figure 2.*—A cut in the Darnell-Talihina complex showing the underlying banded sandstone and shale. Loose sandstone rocks can be seen on the surface.**

The surface layer has a thin cover of recently fallen oak leaves, under which there is a very thin sheet of partially rotted leaves that are penetrated by fungal mycelia. The profile was taken in an area that probably had received some alluvium.

The Pottsville surface soil ranges from fine sandy loam to clay loam, and the subsoil, from clay loam to clay. The underlying shale and clay shale range from olive-brown to dusky red, and from acid to alkaline. The sandstones associated with the shales range from brown to red and from thick bedded to thin bedded. A few small stone-free soil areas on the more gently sloping shelves and benches are somewhat deeper and are thickly wooded or have a fairly thick growth of bluestem.

Use and management (unit VIIs–1).—Nearly all of this complex is used for woodland grazing. Because grass is sparse, the carrying capacity for cattle is low. Tall grasses flourish when the forest is removed, but farm machinery cannot be used on the steep, rocky terrain, and

all clearing must be done chemically or with light power saws.

Spring burning is practiced in some areas to kill oak seedlings and sprouts. This burning encourages the grass to "green up" earlier in the spring, but it also destroys the leaf litter. The soils are left bare and low in potential fertility. The leafy and woody plant remains should be left to become soil humus. If reseeding is attempted, it should be done on the lesser slopes where the soils are deepest and least stony.

Dennis Series

The dark, granular, slightly acid, rolling soils of the Dennis series have developed under bluestem grasses. Their parent material weathered from siltstone, sandstone, and interbedded clay shale of Pennsylvanian age. The soils have a firm, mottled, slowly permeable silty clay or clay lower subsoil. Normally these soils range from 30 to 50 inches in thickness. Their thickness varies according to the slope and the hardness of the underlying rock. These are the major soils in the broad transitional zone between the Reddish Prairie and Prairie soils.

Dennis loam, 2 to 5 percent slopes (Dd).—This is a deep, dark grayish-brown, friable soil that has developed under a cover of bluestem grasses. Nearly a third of it occurs on gently sloping ridgetops, and the rest is on rolling uplands or on foot slopes below the stony prairie soils. This is a major soil in the eastern two-thirds of the county; it occurs in both large and small areas.

This soil is associated with the Parsons soils on the broad benches and upland flats. It has a subsoil less clayey and compact than that of the Parsons, which is a claypan soil. Soils of the shallow and stony Sogn, Talihina, and Collinsville series occur along drainageways, on escarpments, and on stony ridgetops among the broad areas of the Dennis soil. This soil is commonly associated with the Bates soil, but it has a more clayey and more slowly permeable subsoil (fig. 3).

Typical profile in a native bluestem meadow on a slope of about 2 percent (300 feet east of southwest corner of SE¼ sec. 31, T. 21 N., R. 8 E.):

0 to 9 inches, dark grayish-brown (10YR 4/2; 2.5/2, moist) loam; moderate medium granular structure; friable; permeable; medium acid (pH 6.0); contains many worm casts; grades to layer below.

9 to 18 inches, brown (7.5YR 4/3; 3/2, moist) clay loam faintly specked with strong brown; strong medium granular structure; friable; permeable; medium acid (pH 6.0); contains numerous pinholes, insect casts, and worm casts; grades to layer below.

18 to 30 inches, brown (7.5YR 5/3; 4/3, moist) silty clay mottled with 5 to 10 percent strong brown (7.5YR 5/8) and red (2.5YR 4/8); compound fine subangular blocky and weak medium prismatic, the lower 8 inches more blocky than the upper part; firm; slowly permeable; slightly acid (pH 6.5); contains many rounded black pellets, some worm casts, and a few small, rounded fragments of siltstone and sandstone; grades to layer below.

30 to 44 inches, reddish-brown (5YR 4/3; 3/3, moist) silty clay coarsely mottled with reddish yellow (5YR 6/8), red (2.5YR 4/8), brownish yellow (10YR 6/6), and light gray (10YR 7/2); weak blocky; firm; slowly permeable; slightly acid (pH 6.5); contains thin seams of brown sandstone and numerous black concretions; grades to layer below.

44 to 52 inches, coarsely mottled reddish-brown, red, brownish-yellow, and light brownish-gray silty clay; weak blocky; firm; slowly permeable; neutral (pH 7.0); contains thin seams of brown sandstone and is strongly splotched with very dark brown iron stains.

52 to 70 inches+, mottled reddish-brown, brownish-gray, brownish-yellow and red silty clay shale with bands of sandy clay loam; thin bands of sandstone are not distinct but occur throughout the clay shale; abrupt transition at 70 inches to brownish-yellow (10YR 6/8) soft, fine-grained sandstone that is much harder below the upper 2 inches.

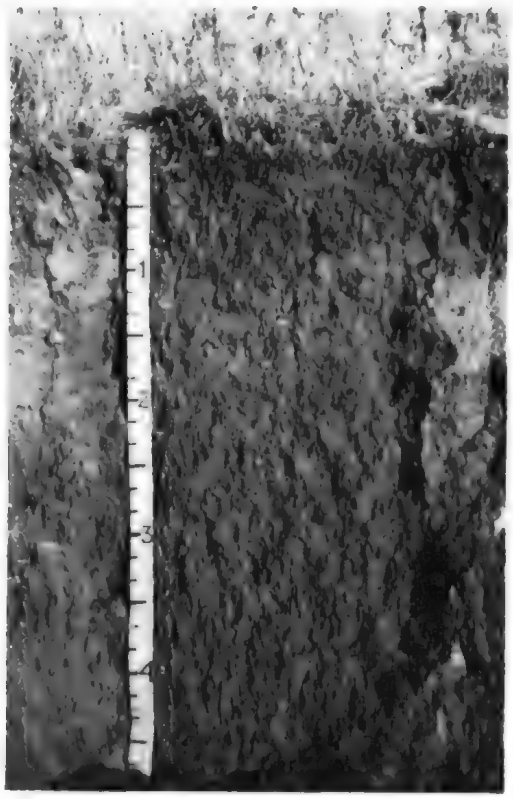

Figure 3.—**Profile of a Dennis loam showing the clayey, slowly permeable subsoil below about 18 inches.**

The texture of the surface soil varies from a loam to a silt loam. The granular upper subsoil ranges from 4 to 10 inches in thickness and from sandy clay loam to silty clay loam in texture. A clayey subsoil occurs at depths of 14 to 24 inches; it varies from subangular blocky to blocky in structure and from slightly acid to mildly alkaline in reaction. In some areas overlying rocks more reddish than normal, the surface soil is brown, the subsoil is reddish brown, and the soil is transitional to the Zaneis and Renfrow soils.

This soil has an unusually thick surface soil and upper subsoil in areas adjacent to the Norge and Vanoss soils. The increased thickness results from silty loess overlapping the shales and sandstones for some distance. Such areas of overlap occur mostly along the fringe of the mantled terrace running from Blackburn through Skedee to Ralston.

Included with this soil, on slopes near the sandstone-capped ridges, are areas of Bates fine sandy loam too small to be mapped separately. Also included, on the gentle slopes, are small areas of Parsons silt loams. In addition, where this soil lies below areas of Talihina and Sogn soils, it includes small, narrow areas of Summit silty clay loam, a soil not mapped separately in this county.

Use and management (unit IIIe–2).—About two-fifths of this soil is now cultivated. Most of the fields are on slopes of 4 percent or less. Nearly one-eighth of the area once cultivated is now going back to grass. Tall grasses occupy most of the uncultivated land, and prairie hay is cut from thousands of acres. Wheat is the principal crop; grain sorghums, cotton, corn, oats, and alfalfa follow in about the order named. Much of the cultivated acreage is used to grow winter feed for cattle.

Water readily soaks into the surface soil but is slowed by the clayey subsoil. Cropland on slopes of more than 1½ percent commonly needs to be terraced because runoff is excessive during heavy rains. If supplies of organic matter and plant nutrients are kept high, this soil is moderately productive of the crops commonly grown. Crops may be injured by drought in summer dry spells because the clayey, slowly permeable subsoil is slow to give up moisture to growing plants. This soil is better for small grains, grain sorghums, and cotton than for corn. Sweetclover, vetch, and Korean lespedeza are grown to some extent; they are good both as soil-improving crops and as pasture.

Native pastures normally are overgrazed. Limited grazing would allow a good portion of the tall grass to seed annually. Areas of abandoned cropland can be reseeded to native grasses, weeping lovegrass, lespedeza, or other pasture plants. The best seedbed for grasses and lespedeza is a trashy mulch.

Dennis loam, eroded, 3 to 5 percent slopes (De).—This soil differs from Dennis loam, 2 to 5 percent slopes, chiefly in thickness of the surface soil. Also, the rills, gullies, and galled areas that expose the subsoil are more evident. This soil is located mostly along small drainage channels and at the heads of drainageways.

Plowing usually penetrates the subsoil and in places turns up shale fragments. Normally the surface soil is splotchy, low in organic-matter content, and from 0 to 8 inches in thickness. This soil is more easily eroded than Dennis loam, 2 to 5 percent slopes, because its absorbent loam surface layer is thinner.

Use and management (unit IVe–1).—Less than one-fifth of this soil is still used for crops, and most of this for small grains and sorghums. Under the best management, the soil can be used for cultivated crops, but under present practices much of the area would be better for some kind of permanent vegetation. A rotation made up of a small grain and sweetclover has been successful for some farmers. Row crops are seldom grown. Grain sorghums supply feed for cattle; they are planted in drill rows or broadcast.

The cover on the older fields is ordinarily thin and consists mostly of annual grasses. Among the annual grasses are the taller bluestems that gradually spread in bunches or clumps. Cattle seem to prefer grasses growing on less eroded areas.

Most areas will benefit if reseeded to native grasses or weeping lovegrass. After stands are established, they should be fertilized to insure good growth and palatability. A stubble mulch or other trashy form of seedbed is best for getting a good stand of grass. Terraces are not needed for areas to be permanently revegetated.

Dennis complex, 5 to 8 percent slopes (Dg).—This complex occurs in narrow bodies around the heads of natural drainageways. It differs from Dennis loam, 2 to 5 percent slopes, in that it is steeper, has a more irregular surface, and is more shallow over bedrock. Outcrops of rock are common. Normally its surface soil is not so deep as that of the Dennis complex on milder slopes, and there are more inclusions of many kinds of associated soils. The Bates and Collinsville are two of the included soils.

Use and management (unit IVe–1).—Most of this complex is in native tall grasses; some is used for meadow. A few small areas once cultivated are now abandoned and returning to grasses. Because of its slow permeability and rapid runoff, this complex is not suited to crops. It is best for pasture and meadow. Grazing should be controlled to allow the tall grasses to reseed annually.

Dennis complex, severely eroded, 3 to 8 percent slopes (Dh).—In this complex are areas of Dennis and Parsons soils that show serious sheet and gully erosion. These eroded areas are around the heads of drainageways or wherever water concentrates. They are characterized by gullies and galled spots. The gullies are from 1 to 3 feet deep and about 100 feet apart. They have cut into the clayey subsoil and, in places, into the clay shale and sandstone beneath. Areas between gullies may have a nearly normal surface soil but are often laced by many shallow rills.

Slick spots with profiles not unlike those of Drummond soils are common on side slopes. It is in these spots that the galled areas normally develop. There are often loose accumulations of calcium carbonate concretions on the galled spots; and sandstone and shale fragments are scattered over the surface. In some transitional areas this complex includes areas of Kirkland and Bates soils.

The severely eroded soils of this complex occur in many small- to medium-sized areas and in many places are associated with eroded phases of Dennis and Parsons soils. The Dennis complex, severely eroded, 3 to 8 percent slopes, is of moderate extent in the county.

Erosion often begins at the places where there are slight changes in slope and the soils are shallow over the underlying shale. Seepage is also evident in these areas. Normally, such eroded areas occur on foot slopes below steeply sloping shallow soils. Water from the soils above has caused the gully erosion. When terraces break, erosion occurs; this should be watched carefully.

Use and management (unit VIIe–1).—These eroded areas cannot be cultivated and their only use is grazing. Except on the areas between gullies where the soil is thicker, stands of tall grass are thin. Grasses become established slowly where the clay is exposed. For greatest improvement, the water above these eroded soils should be diverted. This will allow the gullies to stabilize and gradually reseed to grass. Sprigging with bermudagrass is practiced in many eroded areas.

Nitrogen and phosphate should be applied to all grasses to improve their growth and spread. Grazing should be regulated so that the grasses can reseed annually and can provide a mulch for improvement of the surface soil.

Dougherty Series

In the Dougherty series are undulating to somewhat wavy, grayish-brown, freely permeable, slightly acid soils that have a yellowish-red, clayey subsoil. These soils have developed under oak forests in deep deposits of sandy loam and light sandy loam along the north sides

of the major stream channels. The parent material is old alluvium later covered by loess.

The Dougherty are Red-Yellow Podzolic soils that are transitional to Reddish Prairie soils. They grade toward the Eufaula soils, but the Eufaula have a much deeper, lighter colored, sandier surface layer and thinner more erratic reddish, clayey subsoil. Dougherty soils are similar to the Teller soils but have a deeper, lighter colored surface soil and a more abrupt transition between surface soil and subsoil. In this county they are mostly in the eastern part of the triangle between the Arkansas and Cimarron Rivers.

Dougherty fine sandy loam, 2 to 5 percent slopes (Dk).—This is a sandy, well-drained, slightly acid soil that has developed under a forest growth of black oak, post oak, and hickory. It is limited in extent and occurs mostly as small bodies amid larger areas of more sloping Dougherty soil. Many areas lie adjacent to the small drainageways, normally in areas of slightly wavy relief. This soil is closely associated with the Eufaula soils, and in the transitional areas the texture of its surface layer grades to loamy fine sand.

Representative profile in a woodlot of black oak and post oak on a slope of 8 percent 3½ miles northwest of Keystone (SE¼SE¼SW¼ sec. 10, T. 20 N., R. 9 E.):

0 to 6 inches, grayish-brown (10YR 5/2; 4/2, moist) fine sandy loam; weak granular structure; very friable; permeable; slightly acid (pH 6.8); contains numerous root hairs; grades to the layer below; layer overlain by ¼- to ½-inch layer of leaves and partly rotted leafy residue; slight mixing of this material with upper inch of mineral soil.

6 to 24 inches, light-brown (7.5YR 6/3; 5/3, moist) fine sandy loam; weak granular structure; very friable; permeable; slightly acid (pH 6.2); has many fine roots and some ½- to 1-inch roots; contains filled root channels; abrupt transition to the layer below.

24 to 40 inches, yellowish-red (5YR 5/8; 4/6, moist) light sandy clay; porous; massive; moderately permeable; hard when dry; slightly acid (pH 6.3); contains a number of ½- to 1-inch roots that run laterally; few except main tap roots penetrate this horizon; contains a few grains of medium quartz sand; gradual transition to the layers below.

40 to 82 inches, reddish-yellow (5YR 6/7; 7/7, moist) fine sandy loam streaked with red (2.5YR 4/8); very friable; permeable; red streaks are light sandy clay loam to fine sandy loam; slightly acid (pH 6.5); contains medium grains of quartz sand; at about 72 inches occurs a streak of reddish-yellow light fine sandy loam nearly 6 inches thick.

When cultivated, the surface layer of this soil varies from pale brown to light brown; the surface layer ranges from 8 to 10 inches in thickness on side slopes to more than 30 inches in small swales. In areas of active erosion the surface layer is thinned to the extent that the subsoil is exposed when plowed.

Drainage is good; it is rapid on the surface and medium internally. The soil absorbs water readily but holds only a moderate amount for crops.

Use and management (unit IIIe–3).—More than a third of this soil is in cultivated crops, about half is in old-field pastures, and a small acreage is in oak woodland. The main crops—corn, cotton, grain sorghums, and small grains—are not grown in planned crop rotations. Shallow-rooted crops may be affected by summer drought. Rotations that include vetch and lespedeza are suitable because it is important to maintain the supply of organic matter. Phosphate should be added for row crops and legumes. Nitrogen is needed for crops that do not follow vetch or a similar legume.

Bermudagrass seems best for summer pasture. Vetch and lespedeza are suitable legumes for pasture. Orchards and truck crops also thrive. The soil responds well to fertilizer if the rainfall is adequate. The Dougherty and Eufaula are the only upland soils that support forest stands of any value.

Dougherty fine sandy loam, 5 to 8 percent slopes (Dl).—This soil has a surface that is more wavy than that of Dougherty fine sandy loam, 2 to 5 percent slopes. Nearly 25 percent is severely eroded, but this acreage is not sufficiently eroded to prevent continued cultivation. The eroded areas have a splotchy, reddish surface color and some short gullies and galled spots.

This soil occurs in areas where the terrain is wavy to rolling and strongly dissected. Slopes range mainly from 6 to 8 percent. They do not follow a definite pattern. There are many short, steep slopes and narrow filled swales. The use of large farm machinery is therefore difficult.

Surface runoff is moderate to rapid, and the soil is easily eroded because it has a deep, friable surface soil and subsoil.

Use and management (unit IVe–2). About 25 percent of this soil is in crops, three-fifths in old-field pasture, and the rest in oak forest. Gullying of this soil is hard to check. Terraces using drop inlets for water disposal have been tried in places. This system works if the drop inlets are cared for; however, most of the trials have failed because lack of regular care has allowed undercutting. In general, terracing fails on slopes of more than 6 percent. On moderate slopes, well-built grassed waterways are more successful than drop inlets.

Much of this soil is in orchards. For easier cultivation, trees are grown on the contour. Normally row crops are grown about 1 out of every 3 or 4 years. The fields frequently lie idle between crops. Sweetpotatoes, watermelons, and other special crops are grown in some small areas.

Bermudagrass does well as a pasture plant on this soil and withstands heavy grazing. It is particularly useful as a stabilizing cover on sandy soils such as this. Native grasses grow well after forests have been cleared. On old fields the coarser native grasses come in quickly and spread faster than is normal on the more clayey upland soils. Maintenance of fertility and organic matter and control of johnsongrass are the principal management problems.

Dougherty and Eufaula soils, 8 to 15 percent slopes (Dm).—The steeply sloping soils of this complex are common on the more sandy or coarser textured part of the mantled uplands. They occur on steep slopes, along drainageways, and on the edges of the uplands above the river bottoms. Areas of the Dougherty soil comprise about 50 percent of the complex; the Eufaula, 45 percent; and the Teller, 5 percent. The complex developed under a thick growth of oak forest.

These soils are extremely variable; changes occur within short distances. In places the surface layer appears to be thickened by sandy loess recently blown from the river bottoms. A small portion of Teller soils occurs along the Arkansas River where Teller soils dominate on the adjoining uplands. Here a narrow, forested strip occurs on the "break" to the bottoms, and the soils have a slightly developed profile.

Use and management (unit VIs–2).—About 5 percent of this complex is in crops; 50 percent remains in oak forest. Most areas formerly cropped are now returning to native grasses. Bermudagrass overseeded with Korean lespedeza

will improve the formerly cropped areas. The bermudagrass and lespedeza need light applications of phosphate.

Tall grasses grow well after they are reestablished. Grazing should be controlled to maintain a good cover of grass, because erosion will start on the steep slopes if the plant cover is too sparse.

Eufaula Series

The rapidly permeable, pale-brown sandy soils of the Eufaula series have developed in deep, sandy material from river bottoms. This material is old alluvium, windblown sand, or a combination of the two. The soils have a thin, slightly darkened surface soil and thin bands of yellowish-red sandy clay in the subsoil below depths of 36 inches.

In this county the series occurs principally north of the Cimarron River. The forest growth is redcedar and black, post, and blackjack oaks. The relief ranges from wavy to strongly sloping.

Eufaula loamy fine sand, 1 to 4 percent slopes (Ea).—This is a very friable, slightly acid, sandy soil under a mixed growth of weeds and bluestems. Relief is gently undulating; slopes average about 3 percent.

This soil is closely associated with the Dougherty soils. Boundaries between it and Dougherty soils are broad and gradational. In many places the Eufaula soils have a deep substrata of sandy loam like that under the Dougherty soils, which was overblown by loamy sand.

Typical profile in an abandoned orchard 4 miles northwest of Keystone on a slope of about 6 percent (SW¼NE¼NE¼ sec. 15, T. 20 N., R. 9 E.):

0 to 4 inches, brown (10YR 5.5/3; 5/3, moist) loamy fine sand; very friable; rapidly permeable; slightly acid (pH 6.2); abrupt transition to layer below.

4 to 38 inches, pale-brown (10YR 6/3; 5.5/3, moist) loamy fine sand; rapidly permeable; slightly acid (pH 6.2); a 2-inch transition of brown (7.5YR 4/3, moist) light sandy clay loam to layer below.

38 to 46 inches, red (2.5YR 5/6; 3/6, moist) sandy loam streaked with brown and containing lenses of light sandy clay; clayey lenses are brittle when dry, friable and easily crushed when moist; moderately permeable; slightly acid (pH 6.1); grades to the layer below.

46 to 76 inches +, reddish-yellow (4YR 6/8; 5/8, moist) light sandy clay loam, layered or streaked with light-brown (7.5YR 6/4) light fine sandy loam; aggregate mass is a heavy fine sandy loam; very friable; rapidly permeable; slightly acid (pH 6.5); a few tree roots penetrate into this layer; occasional thin, wavy, brown bands about a quarter of an inch thick occur horizontally in the lower part.

Thickness of the bleached surface layer over the reddish sandy clay loam subsoil ranges from about 30 inches to more than 48 inches. The clayey layers vary from broken seams, ½ to 1 inch in thickness, to layers 8 to 10 inches thick. In areas of deeper sandy materials, these clayey layers are more than 5 feet from the surface.

Some of the areas of more sandy deposits appear to be younger than the surrounding soils and normally lie just above the present river flood plains. A typical area of this kind is in the bend of the Cimarron River, 2½ miles west of Keystone on the south county line. The soil in this area, though mapped as Eufaula, consists of deep light-brown to pink loamy fine sands, which are slightly darkened near the surface. This soil resembles the Derby soil of the sandy grasslands farther west in Oklahoma. It is under oak forest and has a thin ground cover of bluestem.

Use and management (unit IIIe–3).—Nearly 75 percent of Eufaula loamy fine sand, 1 to 4 percent slopes, is cropped to cotton, corn, peanuts, and grain sorghums. The remaining acreage is regrassing or is in stinging nettle, trailing wildbean, and other weeds. This soil produces little because it is rather rough, droughty, and low in fertility.

Water erosion is not a problem on this soil, because of the lack of runoff; however, wind erosion can be a hazard if the fields are left bare during fall and winter. In order to replenish soil nutrients, areas of this soil in Pawnee County are normally cropped 1 year out of 3 or 4 and lie idle between crops.

Orchards, melons, and special crops should do well on this soil if fertilizers are applied properly.

Eufaula loamy fine sand, 4 to 8 percent slopes (Eb).—The small areas of this soil are located mostly in the eastern part of the county. Its relief is wavy to dunelike; slopes are dominantly between 4 and 8 percent, but some range up to 10 percent.

Use and management (unit IVe–2).—Less than 20 percent of this soil is in crops; 40 percent is in old-field pasture, and the remaining area is in oak woodland. Because of its strong, irregular slopes, this soil is seldom farmed in large fields. It is cultivated in many small patches on the most favorable slopes.

Water erosion is a hazard, and terraces are not a practical way to check runoff. Terrace ridges would wash away in the sandy surface soil.

This soil is not suited to row crops, but fair yields have been obtained after an idle period of several years in weeds or after a crop of Korean lespedeza has been plowed under. Rotation of crops is not common, but results elsewhere show that rye and vetch can be rotated successfully with peanuts, cotton, or melons. This system adds some organic matter to the soil, and the rye and vetch prevents wind erosion during winter and early spring.

Orchards and bermudagrass do well if fertilizer is applied. Native grasses come back slowly, and they are coarse and unpalatable during the dry summer. This soil is probably best suited to a forest of black and post oaks, because these trees grow rapidly. Seedling reproduction should be encouraged, and the trees ought to be cut selectively when they are about 16 inches in diameter to forestall heart rot at later stages of growth.

Kirkland Series

Soils of the Kirkland series have a dark grayish-brown, slightly acid, granular, deeply developed surface soil. Their subsoil, a dark, very firm, heavy clay, overlies grayish-brown to reddish-brown, alkaline to calcareous clays. These soils are on gently sloping or nearly level divides in areas underlain by the clayey red beds in western Pawnee County.

The Kirkland are mature soils with a claypan subsoil; however, they are darker and lack the gray layer above the claypan that is in the Parsons soils in the eastern part of the county. In a few areas the Kirkland soils are associated with the more sandy Chickasha soils in areas of similar slope and surface appearance where bedrock

changes from clay to sandstone. The Chickasha soils are not mapped separately in this county.

Kirkland silt loam, 0 to 1 percent slopes (Ka).—This dark grayish-brown, friable, slightly acid soil is of limited extent in the county. It occurs on nearly level areas on upland flats in association with larger areas of the more sloping Kirkland soil. In many places, this soil is associated with Renfrow soils that have redder subsoils.

Other areas of the Kirkland soil occupy low terraces. One deep profile near Panther Creek showed an old soil 42 inches deep that had been covered by the materials from which the Kirkland profile developed.

A few spots on the more level areas that are mapped as Kirkland soil contain inclusions of Tabler soils not large enough to be mapped. These spots have a very dense clay subsoil underlying gray, bleached layers. In the transition between the Dennis and Kirkland soils, some areas of the Kirkland have a granular silty clay upper subsoil that is more rapidly permeable than is normal for Kirkland soils.

Use and management (unit IIIs–1).—Almost 90 percent of this soil is cultivated. The rest is in tall-grass pasture. Wheat is the dominant crop, and it is often interseeded with vetch to increase winter pasture and to furnish active organic matter to the soil.

This soil has moderate surface drainage and very slow internal drainage. Moisture penetrates the upper layers readily, but it moves through the clay so slowly that the soil is too wet to work for 3 to 6 days after a good rain. Shallow ditching is used in a few such areas to remove the water. Terraces to prevent runoff are not required on this soil; however, some areas bordering more sloping soils are terraced.

Small grains, cotton, grain sorghums, and some corn are the principal crops. Alfalfa does well on areas having a thick surface layer. Corn is an uncertain crop because of probable summer droughts. Rotations made up of a small grain and sweetclover or of wheat and vetch are well suited to this soil. Moderate applications of lime and phosphate are required to insure good growth of small grains and legumes.

Kirkland silt loam, 1 to 3 percent slopes (Kb).—This is an extensive soil, the predominant dark-colored soil on broad, gently sloping divides and long gentle foot slopes in the western part of the county. Slopes range from 1 to 4 percent but are mostly less than 3 percent.

Representative profile on a slope of 2 percent in a cultivated field 5½ miles northwest of Pawnee. (NW¼-NW¼NW¼ sec. 1, T. 22 N., R. 4 E.):

0 to 9 inches, dark grayish-brown (10YR 4/2; 2.5/2, moist) heavy silt loam; moderate medium granular structure; friable; permeable; slightly acid (pH 6.2); contains some root hairs and worm casts; a 1-inch transition to the layer below.

9 to 17 inches, dark grayish-brown (10YR 4/2; 3/2, moist) silty clay finely mottled with 5 percent of dark brown (7.5YR 4/4); moderate subangular blocky; very firm; very hard when dry; very slowly permeable; slightly acid (pH 6.5); sides of blocks are faintly shiny and coated with very dark gray (10YR 3/1); grades to the layer below.

17 to 30 inches, mottled dark grayish-brown (10YR 4/2) and dark-brown (7.5YR 4/4) clay; strong medium blocky; very firm; very slowly permeable; neutral (pH 6.8); exteriors of blocks are faintly shiny and very dark grayish brown; layer contains many black ferruginous pellets and a few white particles of gypsum; grades to the layer below.

30 to 42 inches, similar to the layer above but mottled with yellowish brown (10YR 5/6) and dark grayish brown (10YR 4/2); moderately alkaline (pH 8.0); calcareous in seams, though the mass of the material is noncalcareous; grades to layer below.

42 to 86 inches, mottled dark-brown (7.5YR 4/3) and dark reddish-brown (5YR 4/4) calcareous soft clay shale containing calcium carbonate in seams and concretions; contains a few sandy seams; reddish color increases with depth.

The surface soil in some undisturbed areas ranges from 8 to 14 inches in thickness. A few areas that have deeper surface layers are Bethany soils not mapped separately in this survey. Some of this soil has developed on soft clayey material that appears to be a thin alluvial mantle overlying the rocks. If these areas were larger, they would have been mapped as Calumet soil. Such areas occur on smooth uplands west of Pawnee some 50 feet above the present flood plain of Black Bear Creek.

Use and management (unit IIIs–1).—More than three-fifths of this soil is cultivated; the rest is in tall-grass pasture or meadow. The main crops are wheat, grain sorghums, cotton, alfalfa, and corn. Sweetclover is grown for spring pasture and as a soil-improving crop.

If this soil is to be cropped continuously, it should be terraced and farmed on the contour. Nevertheless, a long rotation of wheat and sweetclover can be grown on slopes of less than 2 percent without terracing. This rotation has been used successfully to increase production of small grains, to provide spring pasture, and to raise the fertility of the soil. Most areas of this soil need lime and phosphate.

Controlled grazing of tall-grass pastures should be practiced so that grasses may seed themselves each year.

Kirkland silt loam, eroded, 1 to 3 percent slopes (Kc).—This soil resembles Kirkland silt loam, 1 to 3 percent slopes, but it has a thinner surface soil that averages only about 4 inches in thickness. Because of the thin surface layer, runoff is greater, there is less capacity to store water, and the soil absorbs less moisture.

This soil is of limited extent. Many small bodies occur within larger areas of other Kirkland soils. Many areas are located near the thin Vernon soils along and at the heads of natural drainageways where water concentrates. Water erosion on this soil carries away the surface layer and makes rills, shallow gullies, and galled spots.

Use and management (unit IVe–1).—About 60 percent of this soil is cultivated; the rest is regrassing. Wheat is the main crop. The soil is farmed mostly with larger surrounding areas of other Kirkland soils. Yields are noticeably lower on this eroded soil than on the areas surrounding. A small grain-sweetclover rotation is well suited to this soil. The clover helps to open up the tight subsoil so that moisture can penetrate more easily. Terraces are needed on this soil if it is to be cultivated.

Pasture is probably the best use for most of this soil. Native tall grasses appear to give the best results. They should be established in a sorghum stubble or other trashy mulch that will protect the young seedlings. Soil that is regrassing need not be terraced. Phosphate and nitrogen will encourage growth of grass.

Lela Series

The Lela series is made up of alluvial soils that have a dark-brown or dark reddish-brown, granular surface layer. Their lower layers are similarly colored but

become increasingly reddish with depth. The sediments vary in color and texture but are dominantly reddish silty clays and clays that come mostly from areas underlain by the redbeds formations.

These soils have developed under hardwood forest on the flood plains of the Red Rock and Black Bear Creeks and tributary streams. They often occur near stream junctions where water ponds for a short time during floods.

In this county Lela soils are mapped as one unit—Lela soils.

Lela soils (La).—These dark reddish-brown, friable, slightly acid, clayey soils occur mostly on flood plains of streams and along drainageways. Normally the areas are long, narrow, and fairly large. The soils are of moderate extent in the county.

These soils are closely associated with the Port soil, but they are much more clayey and occupy level areas that have weak, concave surfaces. The Port soil occupies more convex surfaces. The surface layer of the Lela soils resembles that of the Brewer; however, they have no developed clay layer in the subsoil as do the Brewer soils. The clayey nature of Lela soils comes from the fine sediments in which they form, not from the processes of soil development.

Representative profile—Lela silty clay loam—in a large, cultivated area about 1¾ miles north of Lela on a slope of less than ½ percent (SW¼NE¼NW¼ sec. 31, T. 22 N., R. 4 E.):

0 to 16 inches, reddish-brown (5YR 4/3; 3/2, moist) silty clay loam; moderate medium granular structure; friable when moist, sticky when wet; moderately permeable; slightly acid (pH 6.2); abrupt transition to the layer below.

16 to 24 inches, dark-brown (6.5YR 4/2; 2/2, moist) heavy silty clay loam; weak coarse granular structure; slowly permeable; sticky when wet; slightly acid (pH 6.2); aggregate surfaces are *faintly* shiny; 1-inch transition to the layer below.

24 to 32 inches, dark-brown (6.5YR 4/2; 2/2, moist) silty clay; moderate medium subangular blocky; very firm; very slowly permeable; sticky when wet; slightly acid (pH 6.5); fine root hairs penetrate spaces between the aggregates; 2-inch transition to the layer below.

32 to 48 inches, dark reddish-gray (5YR 4/2; 3/2, moist) clay or silty clay; weak blocky; firm; sticky and plastic when wet; very slowly permeable; contains a few fine concretions of calcium carbonate, but soil mass is noncalcareous (pH 6.5); 6-inch color transition to layer below.

48 to 80 inches +, reddish-brown (2.5YR 4/4; 4YR 4/4, moist) silty clay; compound fine subangular blocky and granular structure; very firm; sticky when wet; very hard when dry; contains a number of concretions and threads of calcium carbonate; soil mass is noncalcareous (pH 8.0); layer is less blocky and firm and somewhat more permeable than the layer above.

The texture of the surface soil varies from a silty clay loam to clay. Therefore, the Lela mapping unit is not given a textural name. The finest textured areas are in depressions and along the filled swales that carry waters from adjoining uplands. The upper layer ranges from very dark brown to dark reddish gray, and the substratum, from reddish brown to yellowish red.

In some areas the Lela soils consist of reddish clayey sediments overlying dark buried soils. This upper layer is from 16 to 30 inches in depth and was deposited after changes in the sedimentation pattern of the streams. A dark grayish-brown silty clay loam upper layer and a very dark brown clayey subsoil mark these areas of buried soils. Formerly the dark layers were the surface soil on the flood plains.

Surface drainage varies from slow to very slow. It is adequate for the growth of common field crops except in some areas where water from the uplands collects and is ponded. In such areas crops are planted on ridges that are made by backfurrowing. The quality of these soils is lowered by the inclusions of Drummond "slick spots." These "spots" occur in areas no larger than ¼ acre in size. They are too small to be mapped separately but are indicated by special spot symbols.

Use and management (unit IIw–1).—About 90 percent of these soils is cultivated. The rest is mainly in pasture, but a small area is forested with elm, ash, sycamore, cottonwood, hackberry, and willow. A few native pecan trees are left, and the nuts are harvested each year.

The main crops—wheat, corn, cotton, alfalfa, and grain sorghums—normally are not grown in planned crop rotations. Alfalfa is often followed by a corn crop; small grains are planted after corn, cotton, or sorghums. The supply of moisture may be somewhat low for corn during dry periods in summer.

Alfalfa is being grown on these soils in increasing amounts. It can be established in fall seedings with the aid of lime and phosphate, and it is not affected by excess moisture in spring. Although these soils absorb water slowly and in spring may be too wet to work, they are normally dry enough to allow harvesting the first alfalfa crop in May. The deep alfalfa roots loosen these soils and provide large amounts of valuable nitrogen. Alfalfa is a good soil preparation crop for corn that is to be irrigated. Also, corn yields following a harvest of alfalfa have materially increased. Soil preparation is done in the drier months of fall and winter so that only shallow tillage is needed to ready the land for planting in spring.

Small areas of tall-grass pasture occur in isolated spots that are hard to cultivate, and one or two bluestem areas are in permanent meadows. There are a few pastures on "slick spot" areas where cultivation is not profitable. Such pastures are mostly of grama and buffalo grasses. Johnsongrass, a pest in cultivated fields, is often found in areas not cultivated regularly. Some small pastures are maintained under pecan groves. The forage on many pastures could be improved by complete renovation. The pastures should be planted to mixtures of such tame grasses as bermudagrass and such legumes as Korean lespedeza or possibly vetch. Vetch grows well as winter pasture.

Miller Series

Soils of the Miller series have a very dark brown or dark reddish-brown, granular, clay surface layer and a reddish-brown, slowly permeable clay subsoil. They occur in slightly depressed areas on the flood plains of the Arkansas and Cimarron Rivers. Only one soil of this series is mapped in the county.

Miller clay (Ma).—This is a dark-brown, noncalcareous soil located in long, narrow troughs that lie between bottom lands of the rivers and adjacent uplands. It is commonly associated with the Yahola soils, which are on level to convex surfaces and have a more permeable and less clayey profile.

The Miller soil is often flooded by water from the adjacent uplands. In places it occupies partly filled former stream channels, and these areas may contain wet spots and small ponds most of the year. Surface runoff and internal drainage are slow.

Typical profile in a cultivated, partially filled drainageway in the Arkansas River flood plain about 1 mile east of Cleveland on a slope of less than ½ percent (NW¼SE¼NE¼ sec. 16, T. 21 N., R. 8 E.):

0 to 8 inches, dark-brown (7.5YR 3/2; 2/2, moist) silty clay; moderate medium granular structure; friable to firm; sticky and plastic when wet, very hard when dry; sides of the granules are coated with dark reddish brown (5YR 3/2, moist) and are shiny; upper 2-inch layer is more friable and nearly a silty clay loam; entire layer moderately alkaline but noncalcareous (pH 7.8).

8 to 20 inches, dark reddish-brown (5YR 3/2; 2/2, moist) silty clay or clay, splotched in lower part with reddish brown (5YR 4/3, moist); moderate medium granular structure similar to that of layer above; mildly alkaline but noncalcareous (pH 7.5); 4-inch color transition to layer below.

20 to 36 inches, reddish-brown (5YR 5/3; 4/3, moist) clay; compound subangular blocky and moderate medium granular structure; firm; sticky and plastic when wet; slowly permeable; mildly alkaline but noncalcareous (pH 7.5); sides of aggregate are shiny when moist; grades to layer below.

36 to 52 inches, reddish-brown (5YR 5/3; 4/3, moist) silty clay that is weakly stratified with silty clay loam; friable to firm; less plastic than the layer above; mildly alkaline but noncalcareous (pH 7.5); grades to the layer below.

52 to 78 inches, stratified reddish-yellow (7.5YR 7/6, moist) coarse quartzitic sand and reddish-brown (5YR 4/3, moist) clay loam and silty clay; the finer textures make up about one third of the material; very friable; permeable; mildly alkaline but noncalcareous (pH 7.5).

The soil varies from silty clay loam to clay in texture and from dark brown to reddish brown in color. In places the substratum is banded with sandy layers below depths of 20 to 24 inches, and it ranges from alkaline to calcareous. A few of the wider areas of this soil occur on the level back edges of the bottom lands that are not depressed. Other areas are distinctly depressed and are ponded in wet weather.

Use and management (unit IIw–1).—This soil occurs in many small bodies among larger areas of Yahola soils. Few areas are large enough to use as separate fields, so, ordinarily, the same crops are grown on this soil as on the Yahola soils.

More than 60 percent of this soil is cultivated, 20 percent is in pasture consisting mostly of johnsongrass, and the rest is forested with bottom-land hardwoods. The forests have a shrub understory of redbud, buckbrush, and chittamwood. A thin grass cover grows on the more open woodlands.

The principal crops—corn, small grains, cotton, and alfalfa—produce good yields but in many years are damaged by excess water. Alfalfa can be ruined by water standing on the soil for several days. Corn can be washed out or lodged during floods late in spring. Small grains do well and furnish winter grazing, but mature grain can be injured by floods late in spring.

This soil is well supplied with minerals and should give good yields unless it is flooded. Areas of this soil should be plowed in the fall so that winter freezing and thawing will pulverize the soil and produce a good seedbed. Ample trash mulch should be turned under each year to loosen the soil and prevent surface crusting.

Bermudagrass overseeded with legumes will improve pastures on this soil. Also, such pastures are not harmed by floods so much as the cultivated crops. If maintained as a hay crop, johnsongrass should be rejuvenated by disking or similar cultivation that will loosen the sod mat.

Large trees should be culled from forests periodically to improve the stands. Grazing should be controlled if regeneration by seedlings is desired.

Minco Series

In the Minco series are dark-brown, very friable soils. They have a light-brown to reddish-yellow, very friable subsoil and a reddish-brown to pink substratum. The surface soil and the subsoil have the same texture. No zone of accumulation has resulted from soil development, so the Minco soils are regarded as Regosols. These soils have developed under tall-grass vegetation on the gently undulating bench bordering the Cimarron River flood plain. They lie 15 to 25 feet above the flood plain. The parent material appears to be wind-reworked alluvium.

Some areas of these soils occur on the river side of the bench occupied by the Dale soil. In places the Minco soils extend from the bottoms back to the Dougherty soils on the uplands. The Minco soils lack the bleached lower surface soil and the sandy clay loam subsoil of the Dougherty soils, which have developed under a forest cover. They are darker throughout than the Eufaula soils, which also had a forest cover. The Minco profile is similar to that of the Teller but lacks the developed subsoil of the Teller.

Minco soils, 2 to 5 percent slopes (Mb).—These brown, very friable, slightly acid soils occur in relatively small areas on the bench along the Cimarron River. They somewhat resemble the soils of the Dale series but occupy more irregular surfaces at slightly higher elevations. They are lighter than the Dale and more sandy. Some areas of these soils occur on the river side of the bench occupied by the Dale soil. Slopes range mainly from 1 to 4 percent, though the full range is 2 to 5 percent. Surface runoff is moderate; internal drainage is moderate.

Representative profile 3 miles northwest of Keystone in a formerly cultivated field on a convex slope of 2 percent (NE¼NW¼NW¼ sec. 27, T. 20 N., R. 9 E.):

0 to 12 inches, brown (7.5YR 5/3; 3.5/2, moist) very fine sandy loam; weak granular structure; very friable; rapidly permeable; slightly acid (pH 6.5); grades to layer below.

12 to 50 inches, pink (7.5YR 7/4; 6/4, moist) very fine sandy loam; very friable; rapidly permeable; slightly acid (pH 6.5); grades to layer below.

50 to 80 inches+, pink (7.5YR 5/4; 7/4, moist) light fine sandy loam or loamy fine sand; very friable; rapidly permeable; slightly acid (pH 6.5); banded at about 8- to 10-inch horizontal intervals with reddish brown (5YR 4/4, moist) streaks of fine sandy loam ¼- to ½-inch wide.

The texture of the surface layer varies from coarse silt loam to fine sandy loam; the thickness ranges from 8 to 20 inches. Because of the variable texture of the surface layer the Minco mapping unit is not given a textural name. The substratum varies from light brown to reddish brown or reddish yellow; it is somewhat banded with layers of darker colored silt loam and lighter colored fine sandy

loam. A few erratic bands of light sandy clay loam occur in the substratum. In a few places where these soils lie below the Dougherty soils, the surface is covered by light-brown fine sandy loam washed from above.

Use and management (unit IIIe–3).—These soils are not highly productive because they are droughty in summer when row crops are maturing. However, fair crop yields can be expected in seasons of adequate summer rainfall.

Less than 75 percent of these soils is cultivated. Most of the rest is in old-field pasture that contains johnsongrass, clumps of tall grasses, and annual weeds. Corn and wheat are the dominant crops. A few acres are in cotton and grain sorghums. Alfalfa is grown to limited extent; it gives good yields where it is established. Corn will give a year of good yields if planted in fields that have been in weeds for 2 or 3 years.

Plant nutrients and supplies of organic matter are depleted rapidly under continued cultivation. Planned crop rotations will help to restore organic matter to these soils. Small grains sown with vetch or sweetclover each year are soil-restoring rotations. Phosphate applications are necessary for good growth of legumes. Bermudagrass, overseeded with Korean lespedeza, should do well on these soils, but no areas are planted to this mixture.

Mixed Alluvial Land

Mixed alluvial land (Mc).—This land type is made up of nonarable alluvial sediments of recent origin. It occurs in strips adjacent to the channels of all inland streams. Normally this land type has a broken surface and slopes ranging from 1 to 15 percent or more. The areas are from 100 to 300 feet wide. Even wider areas occur in stream bends and old oxbows.

About 30 percent of most areas consists of stream channels; 10 percent is steeply sloping embankments and edges of adjacent higher lands; 20 percent is recently filled channels; and 40 percent resembles the Port, Yahola, and Cleora soils, with which this land type is associated.

Areas of this land type are dissected by winding former stream channels and include patches of higher lying bottom lands. Narrow bodies occur along drainageways among all of the upland soils. The sediments vary in color from dark brown to yellowish red, and in texture from fine sandy loam to clay loam. The reaction ranges from slightly acid to mildly alkaline.

Use and management (unit Vw–1).—Areas of this land type ordinarily are not suited to cultivation. Locally small patches are in field crops or gardens. This land type will support thrifty forest that can be used for sawlogs. Red oak, black oak, post oak, elm, hickory, sycamore, walnut, cottonwood, and hackberry are the most common. The trees ought to be removed periodically as they mature, and reproduction of hardwoods should be encouraged.

Grasses will produce valuable grazing on the better areas if these are cleared. Because of favorable moisture and fertility, trees and grasses grow rapidly. Many wet clay spots occur, mostly in the oxbows that have been cut off by changes in the stream channel. These spots do not detract from the value of the land for forest or pasture. Bermudagrass does well on lower areas because it withstands silting.

Norge Series

The Norge are dark-brown, granular soils that have a reddish-brown subsoil and a red, clayey substratum. They formed under grass in a mantle of material that is either loess or alluvium. The loess is yellowish-red or red silty clay loam or light silty clay. The alluvium is sandy clay containing a few layers of waterworn gravel and coarse sand. Such gravelly layers commonly are present in the contact area between the old alluvium and the underlying hard sandstone.

This series occurs principally on the flood plains of the Arkansas and Cimarron Rivers and along Black Bear and Camp Creeks. Some areas are 160 to 180 feet above the present flood plains of the rivers and 40 to 50 feet above the flood plain of Black Bear and Camp Creeks. The Norge soils are associated with those of the Vanoss series, but the Vanoss occur on more nearly level areas that have a plane to weakly concave surface. The Norge soils have a lighter colored less deep surface soil than the Vanoss and a more clayey subsoil.

Norge fine sandy loam, 2 to 5 percent slopes (Na).—This brown, very friable soil has a sandy loam surface layer, an upper subsoil of clay loam, and a substratum of sandy clay. It is confined to areas bordering the valley of Black Bear Creek. Normally it occupies gentle convex sloping uplands on a thin mantle of alluvium overlying bedrock.

This soil closely resembles the Teller soils, which were formed in less clayey materials of similar origin. It differs in that it is more strongly developed than the Teller soils and has a slowly permeable subsoil. In Pawnee County the Teller soils occur mainly above the flood plains of the Arkansas and Cimarron Rivers in Pawnee County.

Typical profile in a cultivated field on a slope of 2 percent (NW¼SW¼SE¼ sec. 34, T. 22 N., R. 4 E.):

0 to 10 inches, brown (7.5YR 5/2; 4/2, moist) fine sandy loam or light loam; weak granular structure; very friable; permeable; medium acid (pH 5.5).

10 to 18 inches, reddish-brown (5YR 4/4; 3/4, moist) sandy clay loam; weak granular structure; friable; permeable; medium acid (pH 5.5); contains numerous pinholes and channels left by root hairs; grades to the layer below.

18 to 42 inches, red (2.5YR 4/6; 3/6, moist) sandy clay; compound weak medium prismatic and weak granular structure; friable to firm; slightly acid (pH 6.5); contains considerable quartz sand, a few quartz pebbles, and a few black ferruginous pellets; grades to the layer below.

42 to 50 inches, base of the mantle of old alluvium; similar to layer immediately above but contains more quartz sand and a few waterworn pebbles of quartz and fragments of sandstone up to half an inch in diameter; the texture is a coarse sandy clay or heavy sandy clay loam; slightly acid (pH 6.5); underlain at 52 inches by reddish sandy shale.

The surface soil ranges from 8 to 12 inches in thickness, and the upper subsoil, from 8 to 10 inches. The lower subsoil varies from heavy sandy clay loam to sandy clay in texture and from strong brown to yellowish red in color. The amount of medium and coarse sand in the lower subsoil varies greatly. The amount of sand is greatest in those areas that formed in materials near the base of the mantle. Some small areas contain sand and gravel that can be used in building roads. The mantle ranges from 2 to 6 feet in thickness.

This soil is not extensive. It occurs in small bodies on slopes of 1 to 6 percent. Some 40 percent of it is on slopes of 1 to 3 percent. About 15 percent has been somewhat depleted by sheet and gully erosion. These eroded areas normally are along and near the heads of drainageways.

This soil absorbs water readily, and the substratum holds it in reserve. Areas of less than 3 percent slopes have only a slight risk of erosion; those on 3 to 5 percent slopes are moderately susceptible to sheet and gully erosion.

Use and management (unit IIIe–1).—About 50 percent of this soil is cultivated, nearly 17 percent is abandoned cropland going back to grass, and the rest is in native pasture and meadow. Corn, small grains, grain sorghums, and alfalfa do well.

Areas on slopes of more than 2 percent ought to be terraced and farmed on the contour. This soil needs added amounts of phosphate and increased supplies of active organic matter. Old-field pastures can be improved by seeding to native grasses or to tame grasses and legumes, provided they are fertilized.

Norge silt loam, 2 to 5 percent slopes (Nb).—This dark-brown, slightly acid soil is fairly extensive on convex slopes in the uplands. The dominant range in slope is 2 to 5 percent, but nearly 33 percent of the soil has slopes of 3 percent or less and lies on broad, gently sloping ridges. The rest is on smoothly rounded slopes above the drainageways, where the slope range is 3 to 5 percent.

Typical profile 4 miles west of Ralston in a bluestem meadow on a convex slope of about 3 percent (NW¼NW¼-NW¼ sec. 5, T. 23 N., R. 5 E.):

0 to 12 inches, dark-brown (7.5YR 4/2; 3/2, moist) silt loam; moderate medium granular structure; friable; permeable; slightly acid (pH 6.2); abrupt transition to layer below.

12 to 20 inches, dark reddish-brown (5YR 4/3; 3/3, moist) clay loam; moderate medium granular structure; friable, moderately permeable; slightly acid (pH 6.1); slightly specked with red in the lower part; strong growth of fibrous grass roots; grades to the layer below.

20 to 46 inches, reddish-brown (4YR 4/4; 3/4, moist) silty clay or heavy silty clay loam; moderate medium granular structure; firm; moderately permeable; slightly acid (pH 6.2); aggregates have numerous pinholes and have dark reddish-brown coatings on surfaces; fibrous roots abundant; indistinct transition to the layer below.

46 to 74 inches+, red (2.5YR 5/8, moist) silty clay streaked or coarsely mottled with 10 to 20 percent of light brown (7.5YR 6/4); compound coarse granular and subangular blocky structure; firm; hard when dry; slowly permeable; slightly acid (pH 6.5); contains pinholes and a few fibrous root channels.

The surface soil ranges from 8 to 16 inches in thickness, and the upper subsoil, from 8 to 12 inches. The texture of the lower subsoil varies from silty clay loam to silty clay. Many of the lower areas near the flood plain have a silty clay loam subsoil instead of silty clay; also, these areas have characteristics of both the Norge and Teller soils.

The mantle in which this soil is formed varies from a thin film to as much as 45 feet thick. A normal profile of Norge soil seldom occurs along the edges where the mantle thins out. In areas where the mantle is 2 feet deep over clay and sandstone, the profile ordinarily shows the normal characteristics of Norge soils in the upper layer, but the subsoil is mottled silty clay or clay. Most of such areas were included with the Dennis or Zaneis soils. Separation of Norge and Dennis or Zaneis soils is difficult in transitional zones.

Included with this Norge soil are areas making up about 12 percent of the total acreage that are depleted somewhat by loss of surface soil and presence of shallow gullies. These eroded areas occur on stronger slopes, mainly around the heads of natural drainageways and along the sides of the drains. The risk of erosion in these areas is high, as compared to a moderate risk for the rest of the soil.

Use and management (unit IIIe–1).—Nearly 50 percent of this soil is cultivated, about 17 percent has been retired from cropland, and the rest is in native tall-grass pasture and meadow. This is one of the most productive upland soils. Corn, small grains, alfalfa, cotton, and grain sorghums are the principal crops.

Areas that have slopes of more than 2 percent need terraces if they are cropped continuously. Additions of phosphate are needed to keep the soil productive; also the organic matter must be maintained. The soil responds well to planned crop rotations and other good management.

If phosphate is added, old-field pastures can be improved by planting suitable pasture grasses and legumes.

Norge silt loam, 5 to 8 percent slopes (Nc).—This is an inextensive soil located on the steeply sloping sides of drainageways. Slopes range mainly from 5 to 8 percent but reach 10 percent and average about 7 percent. Because the slopes normally are convex and fairly uniform, they can be tilled easily. Included are areas of this soil totaling about 15 percent that are less productive because of erosion.

Use and management (unit IVe–2).—About 17 percent of this soil is cultivated, some 33 percent has been retired and is regrassing, and the rest is in tall-grass pasture and meadow.

This soil needs careful treatment if it is to remain productive. It is moderately susceptible to erosion even when first cultivated. Erosion increases as the granular surface layer is removed during succeeding plantings. The soil must be terraced and farmed on the contour if cropping is to be continued.

Alfalfa grows well, and the deep roots help to prevent soil erosion on these steep slopes. In some areas orchards do well. At present, most areas of this soil are best suited to pasture. Tall grasses should be preserved and improved by good management.

Norge soils, severely eroded, 3 to 8 percent slopes (Nd).—The small bodies of these soils are located within larger areas of Norge silt loams and Norge fine sandy loam. They are parts of the Norge areas that have been seriously sheet eroded and gullied. These soils have lost all the surface layer in some places, and in others they have a surface layer nearly normal in thickness. The upper subsoil is exposed in large areas, and gullies that are 50 to 100 feet apart have dissected many tracts.

These soils occur mostly on slopes of 4 to 6 percent around the heads of drainageways. Most of them are within a few miles of the Arkansas River. They form where the soft mantling materials are fairly shallow over bedrock. In such areas gullies rapidly cut down to the rock layer. In places these soils begin to form where ridges of a terrace have broken through and water flows down the slope. They occur mostly in areas where normal Norge soils are cut up by water flowing from shallow stony soils on the slopes above. Areas with an exposed subsoil will continue to erode rapidly until some kind of cover becomes established.

Use and management (unit VIIe–1).—Because of the network of gullies on these soils, they are not suited to cultivation. The gully sides have only a thin cover of annual grasses and weeds. Areas between gullies normally have a better cover. The use of diversion terraces on slopes above these soils will allow the gullies to stabilize and reseed to grass. The process can be speeded up by blading down the sides of the gullies. Planting of grass seed or bermudagrass sprigs is also suggested.

Until the grass is established, grazing should be deferred or light. Application of nitrogen and phosphate will encourage the grass to spread.

Parsons Complex

This complex of grassland soil is dominantly Parsons silt loam with minor areas of Dennis, Summit, and Bates soils. Because of the thinly banded rocks, the parent materials vary within small areas. Thus, the clay shales underlying the Parsons soil grade to siltstone or sandstone, and the change is not indicated on the surface. This makes it difficult to separate the Parsons silt loam from the other soils.

From 10 to 30 percent of the complex is other soils, chiefly Dennis, Summit, and Bates soils, that are mapped with the Parsons silt loam. The complex is moderately extensive. It occurs in a number of fair-sized bodies, mostly in the central part of the county on upland flats where slopes range from ½ to about 3 percent. Nearly 10 percent of the complex is on slopes of 1 percent or less.

This complex is mapped in two units, one on slopes of 1 to 3 percent that are not eroded, the other on slopes of 1 to 3 percent that have been eroded.

Parsons complex, 1 to 3 percent slopes (Pa).—These dark grayish-brown soils have a very dark brown, tough, plastic claypan and a mottled grayish-brown lower subsoil that is medium acid to neutral. They have developed under grasses in gray, brown, and red clay shales of Pennsylvanian age and are classed as Planosols.

The Parsons soils of this complex occur on level and weakly convex surfaces and overlie clay shale, but the associated Dennis soils occupy gently undulating to sloping surfaces and overlie interbedded siltstone, sandstone, and clay shale. The Parsons also differ from the Dennis soils in having a more clayey subsoil that lies abruptly below the surface soil. The Parsons resemble the Kirkland soils but have a slightly less dark and less granular surface soil. Also, in the Parsons soils, there is a more abrupt transition from surface soil to subsoil. The Parsons soils have a bleached lower surface soil that is lacking in the Kirkland. Parsons soils are somewhat like the Renfrow but they have a grayer surface layer, a less reddish and more plastic subsoil, and more gentle slopes.

Profile 9 miles southeast of Pawnee, in a tall-grass pasture on a slope of 1 percent (SE¼SW¼NW¼ sec. 28, T. 21 N., R. 6 E.):

0 to 13 inches, grayish-brown (10YR 4.5/2; 3/2, moist) silt loam; moderate medium granular structure; friable; moderately permeable; granules are soft when moist and crumble to single grains under slight pressure; medium acid (pH 6.0).

13 to 15 inches, grayish-brown (10YR 5/2; 3/2, moist) silt loam; moderate medium granular structure; friable; sides of aggregates filmed with light brownish gray (10YR 6/2); medium acid (pH 6.0); rests abruptly on the layer below.

15 to 26 inches, very dark brown (8.5YR 3/2; 2/2, moist) clay specked with strong brown (7.5YR 5/5); weak medium blocky; extremely firm; very hard; very slowly permeable; slightly acid (pH 6.5); strong clay films; grades to the layer below.

26 to 44 inches, brown (7.5YR 5/3; 4/3, moist) clay; weak blocky; very firm; very hard when dry; very slowly permeable; mildly alkaline but noncalcareous (pH 7.5); contains specks of strong brown and yellowish brown; sides of aggregates have weak clay films; layer contains a number of fine concretions of lime and several large ones; concretions are concentrated in cracks between aggregates; layer also contains a few pieces of sandstone and siltstone and many fine, rounded black pellets; grass roots penetrate mostly along cleavage planes; grades to the layer below.

44 to 68 inches, reddish-brown (5YR 4.5/4; 3.5/4, moist) clay specked with yellowish red; friable to firm; slowly permeable; hard when dry; mildly alkaline (pH 8.0) but noncalcareous; crumbly when moist; contains a few fine lime concretions, many fine, rounded black pellets, and a few rounded fragments of siltstone; grades to layer below.

68 to 86 inches, reddish-brown (2.5YR 4/5; 3/5, moist) calcareous clay mottled or streaked with pink (5YR 7/3); moderately fine blocky clay shale with shiny sides where the bedding planes contact; firm to friable when moist; slowly permeable; contains many lime concretions and a few small, rounded black pellets; some iron staining occurs around concretions and pellets.

The surface soil varies from 6 to 14 inches in thickness and from loam to heavy silt loam in texture. The surface in places is noticeably gray after cultivation, and it dries to light brownish gray. The gray films on the aggregates in the lower part of the surface soil, just above the claypan, are lacking in many places or are only slightly evident. This is particularly true in the more reddish areas of the Parsons soils. Where the subsoil develops in reddish shale, as in the central part of the county, it is reddish brown and the sides of the blocks have a dark-brown coating of clay and organic material. In general, soils in this complex range from 30 to 48 inches in depth; they are more shallow in places where the underlying shale is most clayey.

Drainage is slow from the surface, and water passes very slowly through the claypan. The soil above this claypan often becomes saturated after a good rain because the pan is very slowly permeable. There is a moderate risk of erosion on slight slopes because runoff begins when the soils are saturated.

Use and management (unit IIIs-1).—Nearly 60 percent of the complex is cultivated, 10 percent is in old-field pasture, and the rest is covered with native bluestem used for pasture and meadow. The main crops—small grains, grain sorghums, cotton, and corn—produce only moderate yields. The soils are normally low in phosphorus and organic matter, and the crops are affected by droughts late in spring and in summer. Parts of the complex that have been cultivated for a long time have a number of "slick spots" one-tenth of an acre or larger in size.

Most areas that are to be used often for row crops should be terraced and farmed on the contour. Yields have been increased lately by rotating a small grain with sweetclover and by growing wheat and vetch together. Old-field pastures, normally in poor condition, can be improved by plantings of bermudagrass, Korean lespedeza, native or improved tall grasses. Terraces are not desirable on areas to be regrassed. Native pastures must be carefully stocked to prevent overgrazing. The Parsons soils of this complex will not stand heavy grazing so well as the Dennis soils. Grasses do not root so deeply on the soils of this

complex as they do on more permeable soils, nor do they stand trampling so well.

Parsons complex, eroded, 1 to 3 percent slopes (Pb).—Soils of this complex are of limited extent. They occur mostly around the edges and heads of shallow drainageways. The soils are much like those of the Parsons complex, 1 to 3 percent slopes, but they have lost several inches of the surface layer. This layer now is only 4 to 5 inches thick. Also, there are a number of shallow gullies and more "slick spots" than in the soils of this complex on milder slopes. Because of these scattered shallow gullies and galled areas, from 10 to 20 percent of this complex cannot be used for crops.

Use and management (unit IVe–1).—Crop yields are medium to poor on these soils; therefore, about 66 percent of the complex is in some stage of regrassing. The soils are droughty. They are normally in small bodies among larger areas of the Parsons complex. They are easily eroded because the absorptive surface layer remaining over the claypan is so thin. Normally the cultivated eroded areas of this complex are used in the same way as the surrounding areas of Parsons soils.

Small grains are the main crops. A few areas are used for sorghums and cotton, but seldom for corn. The thin surface soil above the claypan cannot provide ample plant nutrients and moisture for good growth of summer crops. Spring-growing clover and drought-resistant native grasses do better on these soils than common field crops. Also, over a period of years, they may produce more forage at less cost than is produced by field crops. Terraces are not suggested for areas to be permanently regrassed.

Port Series

Soils of the Port series have developed in noncalcareous reddish-brown sediments carried down by streams draining grassland soils. Port soils occur throughout the county but they are developed most typically in the western part. These are alluvial soils; they are typically silt loam or clay loam and have a clay loam substratum somewhat stratified with silt loam.

In places these soils resemble the youthful Vanoss soils that have developed in underlying material much like that of the Port. Normally the Vanoss soils occur on higher benches, but where Port and Vanoss soils adjoin it is hard to separate them on the basis of soil characteristics alone.

In most places the Port soils occur on the flood plains of streams that drain areas of Renfrow, Zaneis, and Vernon soils. In other areas the Port soils are a little darker than normal. Locally they may have slight profile development. This shows that there has been little or no material deposited recently and that the sediments have been in place for some time. One soil of this series is mapped in the county.

Port silt loam (Pc).—This is an extensive soil. It occurs on the flood plains of all the inland streams of the county.

This reddish-brown, permeable soil normally occupies fairly level areas, but it has adequate drainage. Water seldom stands in pools. A few areas of this soil are slightly wavy, but they can be cultivated easily and yield about the same as the level areas.

This soil differs from the Yahola soils in having a more clayey substratum, slower drainage, and less overflow. It is less sandy and more reddish than the Cleora soil, and it occurs higher on the flood plains.

Typical profile from a cultivated field on a slope of ½ percent (SW¼NW¼NW¼ sec. 32, T. 22 N., R. 5 E.):

0 to 10 inches, reddish-brown (5YR 4.5/3; 3/2, moist) silt loam; weak medium granular structure; friable; permeable; neutral (pH 7.0); 2-inch transition to the layer below.

10 to 28 inches, reddish-brown (5YR 4/3; 3/3, moist) light silty clay loam; moderate medium granular structure; slightly firm; permeable; hard when dry; contains numerous pinholes and worm casts and a few fine pebbles of quartz; neutral (pH 6.6); indistinct transition to the layer below.

28 to 60 inches +, reddish-brown (5YR 4/3; 3/4, moist) silty clay loam specked with 5 percent or less of yellowish red; moderate medium granular structure; firm; moderately permeable; hard when dry; contains many pinholes and worm casts; neutral (pH 6.6); becomes slightly lighter in color below 50 inches.

The surface layer and the substratum vary in color from very dark brown to reddish brown. However, on the fringes of the high-lying flood plains along Camp and Coal Creeks, this soil has a very dark brown surface layer and a very dark grayish-brown substratum. This probably represents inclusions of slightly developed Mason soils that form in dark-colored alluvium on very low terraces.

Some areas mapped with this soil occur below the dark-colored Sogn soils and are undoubtedly affected by colluvium from those soils. The profile of these areas has about 12 inches of very dark brown silt loam that grades to very dark brown granular clay loam. Below depths of 24 to 30 inches, this material becomes less dark and has strong-brown specks. A few areas of this soil contain layers of silty clay; these occur locally where the drainage comes from the Vernon soils.

Buried soils commonly occur in the Port series and are numerous in other places throughout the county. These buried soils are indications of periods of stability in an older bottom land and are normally very dark grayish-brown silt loam or silty clay loam. They lie 18 to 30 inches or more below the surface. Above this depth, the sediments are usually browner or more reddish. The buried soils indicate a change in the erosion cycle in the upland areas.

Use and management (unit I–1).—About 86 percent of this soil is cultivated; 10 percent is in bluestem grass; the rest is in forests of red and black oaks, green ash, sycamore, hackberry, American elm, walnut, and pecan. There is a shrub understory of redbud, rough-leaved dogwood, and serviceberry. Grass is sparse in the ground cover.

The principal crop is corn. Wheat, cotton, alfalfa, and oats follow in about the order named. Floods seldom harm standing corn, but sometimes they damage mature small grains. Yields are good to excellent on this soil and are normally dependable each year.

This soil responds well to management. Fertilizer, applied at time of seeding and as a sidedressing, will benefit this soil. Use of legumes in the crop rotation is desirable. This is one of the few soils in the county on which furrow irrigation can be practiced. Irrigation greatly increases yields of corn. This soil can produce much larger yields than it does under present management.

The pasture areas, most of them small irregular tracts, normally are used with surrounding higher lying pastures. Tall-grass pastures are thrifty but must be carefully stocked to prevent overgrazing. Some grass should be

allowed to go to seed annually. Trees suitable for fence posts—catalpa and black locust—can be planted in the small irregular areas on these bottoms.

Renfrow Series

Soils of the Renfrow series have a granular dark-brown or dark reddish-brown surface soil and a blocky reddish-brown clay subsoil overlying alkaline to calcareous soft red clay. These well-developed soils have a semiclaypan subsoil that has formed under medium-height and tall grasses. These soils are derived from clayey "red beds" and are on undulating topography.

On the steep slopes above drainageways and on the escarpments, the Renfrow soils grade to the Vernon soils. The Vernon are shallow soils that have developed in calcareous redbeds. Where the clayey beds give way to soft reddish sandstone and sandy shale, the Renfrow soils are succeeded by Zaneis soils. The Zaneis soils have a subsoil of clay loam or light clay that is granular and more permeable than the subsoil of the Renfrow soils.

Renfrow silt loam, 1 to 3 percent slopes (Ra).—This moderately extensive soil occurs mostly on ridgetops in the western part of the county. It has a reddish-brown permeable surface layer and a dark reddish-brown very slowly permeable subsoil. The soil is on convex slopes. The dominant range in slope is 1 to 3 percent, the maximum is about 3½ percent, and the average slope is 2 percent.

On gentle side slopes this soil is associated with and grades to smoother areas of the darker colored Kirkland soils. The Kirkland soils have a darker, less reddish surface layer and upper subsoil than the Renfrow and are more deeply developed.

The erosion risk is very slight on this Renfrow soil where it has a grass cover. If it is cultivated, there is moderate risk.

Profile about 10 miles northwest of Pawnee on a convex slope of 3 percent under a cover of native bluestem grass (SE¼NE¼NE¼ sec. 10, T. 22 N., R. 3 E.):

0 to 12 inches, reddish-brown (5YR 4/3; 2.5/2, moist) silt loam; moderate medium granular structure; friable; permeable; slightly acid (pH 6.5); abrupt transition to layer below.

12 to 24 inches, dark reddish-brown (5YR 3/4; 3/3, moist) clay; moderate medium blocky; very slowly permeable; sticky and plastic when wet; neutral (pH 7.0); sides of aggregates are shiny; indistinct transition to layer below.

24 to 36 inches, reddish-brown (2.5YR 4/4; 3/4, moist) clay; moderate medium blocky; very slowly permeable; alkaline but noncalcareous in the mass; contains seams of calcium carbonate and a few black particles of weathered sandstone; blocks have shiny sides; indistinct transition to layer below.

36 to 52 inches+, weak-red (10R 5/3; 4/3, moist) shaly clay streaked with pale red (10R 6/3) and pink (5YR 7/3); calcareous; contains seams of soft sandstone, particles or crystals of gypsum, a few narrow bands of calcium carbonate concretions, and a few black ferruginous concretions; underlain at a depth of 52 inches by fairly thick, hard sandstone; material in this layer is slightly altered Permian redbeds clay.

The surface soil ranges from fine sandy loam to heavy silt loam in texture and from dark brown to dark reddish brown in color. In some areas a gradational layer of clay loam 3 to 4 inches thick overlies the blocky clay subsoil; in other places the subsoil is heavy sandy clay layered by more plastic clay.

Near Lone Chimney a number of areas mapped as Renfrow soil are transitional to the Dennis or Zaneis soils. These areas have a dark-brown surface soil and upper subsoil and a grayish-brown to reddish-brown clay subsoil. Because this subsoil is seamed with sandstone, it is more friable in places than the typical Renfrow subsoil. Locally there are a few clay bands of brownish gray to pale yellow. From these bands of clay a soil develops that has a gray subsoil. This subsoil has a soapy feel when crushed.

Renfrow silt loam, 1 to 3 percent slopes, absorbs water readily into its surface layer but very slowly into its subsoil. Water may be scarce for summer crops because the heavy clay subsoil prevents water from moving toward the surface.

Use and management (unit IIIs–1).—Half of this soil has been cultivated at some time, and only a small part of this has been retired. About 50 percent of the soil is now in native tall grasses and gramas used for pasture and meadow. The principal crops are wheat, grain sorghums, and cotton. This soil needs added amounts of phosphate and increased supplies of active organic matter. On slopes of 1½ percent, or more, terraces are needed if the soil is cultivated.

A small grain-legume rotation is well suited to this soil. Vetch and wheat grown together are good for winter pasture and for green manure. Controlled grazing of native pastures should be practiced so that grasses may seed themselves each year.

Renfrow silt loam, 3 to 5 percent slopes (Rb).—This soil is located on sloping uplands and on foot slopes below areas of Vernon soils. It is a little less deeply developed than the Renfrow soil on the gentler slopes. Normally it is also more variable and has more inclusions of Zaneis and other soils.

The soil occurs in both large and small bodies. The dominant range in slope is 3 to 5 percent, but the extreme range is 2 to 6 percent. The average slope is about 4 percent.

Use and management (unit IVe–1).—Less than 25 percent of this soil is cultivated; nearly all the rest is in native tall grasses and gramas used for pasture and meadow. A small acreage is abandoned cropland going back to grass. Large areas of pasture are on this soil in Otoe Township; these are owned by the Indians and are leased only for grazing.

Terraces are needed on this soil if it is used for tilled crops, but they are not needed if it is permanently regrassed. The risk of erosion is moderate if the soil is used for small grains, but it is high if clean-tilled crops are grown.

Wheat, grain sorghums, and cotton are the principal crops. Wheat and vetch are being grown together on larger acreages, as they are useful for winter pasture and as green-manure crops. In most areas row crops are grown only once in every 3 or 4 years. A rotation made up of a small grain and a legume has been used successfully to build up soil fertility.

Renfrow silt loam, eroded, 3 to 5 percent slopes (Rc).—This soil occurs in a number of fairly small bodies within larger areas of uneroded Renfrow soils. It is found around the heads of drainageways where water accumulates.

This soil is similar to Renfrow silt loam, 3 to 5 percent slopes, but erosion has reduced the depth of its surface

soil. The surface layer ranges from 2 to 8 inches in thickness and averages about 5 inches. Most areas have a number of shallow gullies and a few galled spots that expose the red, clayey subsoil. Water soaks into this soil more slowly than into the uneroded Renfrow soils. Erosion risk is high if the soil is cultivated.

Use and management (unit IVe–1).—One-third of this soil is cultivated; the rest is abandoned cropland going back to grass. Because the soil occurs among larger areas of uneroded Renfrow soils, it is cultivated in the same way. Yields are less, however, because the soil is low in organic matter and has limited space to store water above the clay subsoil.

Small grains are best for this soil, because they make their growth early in spring when moisture is normally adequate. Terraces are needed if this soil is to be cultivated, but not if it is to be in grass. In some cases permanent pasture is the best use. Native tall grasses and gramas can be reseeded under a trash mulch. Sorghum stubble, for example, will protect the grass seedlings. Applications of phosphate and nitrogen will improve growth of pasture plants.

Renfrow soils, severely eroded, 3 to 5 percent slopes (Rd).—This mapping unit contains relatively small tracts of severely eroded Renfrow soils, which occur within larger areas of Renfrow silt loams. Sheet and gully erosion have reached an advanced stage on these soils. In many places the gullies are 2 to 3 feet deep and 10 to 15 feet wide. They occur at intervals of 100 feet or less. In places gullies have cut down to the soft red clay and sandstone parent material. Many of the areas between the gullies have a nearly normal soil, as much as 6 to 8 inches of surface soil in some places. Toward the gully sides the surface soil thins until it is gone completely. In these areas the blocky reddish-brown clay subsoil forms the surface layer.

Shallow galled areas lacking a surface soil and an upper subsoil are common; they can be recognized by concentrations of loose calcium carbonate concretions on the surface. These galled areas often start as slick spots. The spots have the shallow surface soil and a blocky clay subsoil characteristic of the Drummond series.

This mapping unit occurs mostly in medium- to small-sized bodies. Most areas occur on slopes of 4 to 5 percent near the heads of drainageways. Here the water descending from the sides concentrates and forms gullies. Included in a few places are small areas of Kirkland soil that have been severely eroded.

Risk of erosion is high on these Renfrow soils. If it is not checked, the soils rapidly become worse and contribute large silt loads to ponds and bottom lands.

Use and management (unit VIIe–1).—All of this mapping unit is unsuited to cultivation. With good management, it will return to grass. Normally tall grasses are thin or lacking near gullies but moderately thick between them. Diversion of water will allow the gullies to stabilize and the growth of grass to improve. Gully sides can be sprigged with bermudagrass; for good growth, nitrogen and phosphate should be added. Mulches of any kind will be useful. Tall grass cut late for seed can be left on the ground as a mulch. The seeds will help start a new growth of grass in the mulch. When annual grasses get started, control grazing so that there will be seed for next year and a mulch to protect the soil.

Sandy Alluvial Land

Sandy alluvial land (Sa).—This is a miscellaneous land type comprised of sandy alluvial sediments of recent origin that lie along the channels of the Arkansas and Cimarron Rivers. It is moderately extensive and occupies a frequently overflowed strip that lies 5 to 10 feet above the normal water level of the channel. A few areas formed where the river channel had shifted recently. Locally, these areas cover blocks of 40 acres or more.

The surface is made up of ridges lying parallel to the river and 3 to 6 feet above the intervening swales. In general, the ridges are about 100 feet apart and are composed of sandy materials; the narrow swales are filled with silty or clayey materials. The material on the ridges is normally a pale-brown loamy fine sand. Thin lenses of brown or dark-brown fine sandy loam or silt loam occur in the lower part. In the swales the sediments are dark-brown or reddish-brown heavy silt loam or clay loam stratified with sandy loams and clays. The sediments are alkaline to calcareous.

On the ridges the convex slopes range from 2 to 6 percent. In the swales the slopes are concave. Drainage from the ridges is rapid; from the swales it is slow to very slow, and they are moist a good deal of the time.

Along the Cimarron River areas of this land type are normally narrow, less distinctly ridged, and somewhat less sandy than those along the Arkansas River. They are reddish brown and yellowish red instead of pale brown. The swales are wider in proportion to the width of the low ridges. The swales are usually filled with silty clays and are very slowly drained. In many places they are covered by nearly pure stands of willow; tamarix is also common and occurs on bare riverwash in some areas.

Use and management (unit Vw–1).—A few areas of this land type are cropped and used with Yahola fine sandy loam, which lies several feet higher. Row-crop farming is not successful on this land because it is frequently flooded and is usually overrun with johnsongrass. Attempts at cultivation are soon abandoned.

The best use for this land is forest. It has a heavy growth of cottonwood, American elm, green ash, sycamore, hackberry, red and black oaks, and willow trees. Proper cutting and planting should be practiced in order to encourage the more desirable kinds of trees. Black locust and catalpa, suitable for fence posts, grow well on this land because of the high water table and good natural fertility. These trees are best planted after the mature hardwoods have been removed. They should be located on ridges that drain well after floods. After a 3-year growth, there is little danger of losing the trees through silting..

Most of the open areas are in johnsongrass and weeds. Also common are spots of recently deposited pale-brown loamy sands bare of any vegetation. In a few places bermudagrass grows in openings and under open forest. This makes good pasture but calls for a good bit of fencing in order to use these long, narrow areas separately from the bottom-land fields. Floods may endanger cattle in these pastures.

Sogn, Talihina, and Collinsville soils

This is a complex association of shallow prairie soils that have developed over various kinds of rocks. The

rocks are of Pennsylvanian age and are characteristically thin bedded. For this reason there is wide local variation in the kind of rock and in the soil developing thereon.

Sogn soils have developed in gray, olive, and brown alkaline to calcareous shale and interbedded limestone. Talihina soils have developed in gray and brown acid shale and interbedded brown sandstone. The Collinsville has formed in sandstone and interbedded siltstone, mostly on ridges of moderate slope. Sogn soils and Talihina soils are more commonly on escarpments and stronger slopes.

Sogn, Talihina, and Collinsville soils, 3 to 20 percent slopes (Sb).—These soils cover a wide area on sloping and strongly rolling tracts in the eastern two-thirds of the county. Normally the mapping unit is about 45 percent Sogn soils, 35 percent Talihina, and 20 percent Collinsville. Areas underlain mostly by limestone normally have the highest amount of Sogn soils; other places have little or none of these soils. The Sogn are most common in the north-central and central areas of the county; the Talihina in the eastern part. On the ridgetops Collinsville often occurs in nearly pure bodies. On steeper slopes the Collinsville is normally of small extent and is associated with the Sogn soils, Talihina soils, or both.

The Sogn soils have a very dark, granular surface layer and a mottled olive-brown, grayish-brown, and yellowish-brown clay subsoil. They are normally covered with chips and slabs of limestone. They have either limestone or calcareous clay shale at shallow depths. The Sogn soils are closely associated with the Summit soils, which occupy adjacent foot slopes. The Summit are deep soils that come from similar parent materials. Sogn soils occur on slopes ranging from the extremes of 3 to 20 percent, but they are mostly on slopes between 8 and 15 percent.

In the area of the representative profile, drainage is rapid from the surface but slow through the soil. The surface layer is very stony. In some places limestone bedrock is 1 to 3 inches below the surface. The dominant grasses are silver beardgrass, switchgrass, Indiangrass, and big and little bluestems. A few wild legumes are evident. In places persimmons and sumac have invaded these soils.

Representative profile of Sogn stony clay loam under a native grass pasture 4½ miles southeast of Skedee on a 12 percent slope (NE¼SE¼NE¼ sec. 7, T. 21 N., R. 6 E.):

0 to 5 inches, dark grayish-brown (2.5Y 4.5/2; 3/2, moist) heavy silty clay loam; strong medium granular structure; friable; permeable; mildly alkaline (pH 7.5); contains numerous fine, pale-yellow fragments of hard limestone; about 20 percent of the surface layer is covered with flags of gray, hard limestone; grades to layer below.

5 to 22 inches, mottled olive-brown (2.5Y 4/3) and light olive-brown (2.5Y 5/5) calcareous clay; coarse granular or subangular blocky structure; friable to firm; slowly permeable; scattered through clay are thin, 1- to 2-inches, layers of hard limestone; colors slightly lighter in the lower part, but the layer is only slightly altered clay shale.

The Sogn soils vary from 1 to 18 inches in total thickness. They are shallowest around the limestone outcrops and deepest in areas overlying soft clay shale. The substratum varies from olive gray to reddish brown. In several areas on the tops of ridges, the limestone lies at the surface. Little soil has developed in these areas. Seepy spots are common on side slopes.

The Talihina soils have a dark, granular surface layer. Their grayish-brown or brown clay or silty clay subsoil is mottled with red and brown; it is not very deep over the clay shale. Normally, flaggy sandstone covers the surface. The soils occur on slopes ranging between the extremes of 3 and 20 percent; the dominant slopes are between 8 and 15 percent. The soils are associated with the Dennis soil, a deep soil formed from similar interbedded clayey and sandy parent materials.

Drainage of the Talihina soils is rapid from the surface but slow through the soil. Tall grasses and sumac do well at the site of the representative profile. In other places persimmons have invaded.

Typical profile of Talihina soil under a native grass pasture on a slope of 12 percent (NE¼NE¼NW¼ sec. 34, T. 21 N., R. 8 E.):

0 to 6 inches, dark grayish-brown (10YR 4/2; 2/2, moist) silty clay loam; strong medium granular structure; friable; permeable; slightly acid (pH 6.2); contains chips of brown sandstone about ¼- to ½-inch thick in lower part; grades to layer below.

6 to 16 inches, brown (7.5YR 5/4; 4/3, moist) silty clay finely mottled with reddish brown (5YR 4/4) and dark brown (7.5YR 4/4); strong medium subangular blocky structure; firm; slowly permeable; sticky and plastic when wet, very hard when dry; slightly acid (pH 6.2); contains chips and angular slabs of brown sandstone; material in the layer is only slightly weathered shale of silty clay texture that grades to the underlying shale.

16 to 30 inches, grayish-brown (10YR 5/2; 4/2, moist) clay shale strongly mottled with red (2.5YR 4/6), reddish brown (5YR 4/4), and light yellowish brown (10YR 6/4); neutral reaction (pH 6.7).

In other areas of Talihina there are variations from the foregoing profile. Soil thickness ranges from 2 to 16 or 18 inches, and there is a wide range in the number of sandstone slabs and fragments on the surface. The shales vary in color and in thickness of beds and range from slightly acid to mildly alkaline; the acid members are by far the most prevalent. The amount of sandstone in the mixture also varies widely, as does the percentage of Collinsville soil in close association with the Talihina.

The Collinsville soils have a dark-brown, granular surface soil underlain by brown, yellowish-brown, or reddish-brown sandstone at shallow depths. They are associated with the Bates soil and to some extent with the Dennis. In transitional areas they become more like the Darnell soils. Drainage is moderate from the surface and rapid through the soil. Bluestem grasses and smooth sumac grow well on these soils. Sumac and persimmon have invaded in places.

Representative profile of Collinsville soil under a tallgrass meadow 5 miles southwest of Cleveland on a convex slope of 3 percent (SE¼SE¼NE¼ sec. 34, T. 21 N., R. 7 E.):

0 to 8 inches, dark-brown (7.5YR 4/2; 3/2, moist) loam; strong medium granular structure; friable; permeable; contains a few small fragments of weathered sandstone; slightly acid (pH 6.2); aggregates slightly reddish brown when crushed; grades to the layer below.

8 to 30 inches, reddish-yellow (7.5YR 7/6; 6/6, moist) soft partially weathered sandstone occurring in seams about 1 inch thick; stained with reddish brown and yellowish red and interlayered with seams of dark-brown loam; slightly acid (pH 6.5).

Between depths of 20 and 26 inches there is a layer of reddish-brown silty clay streaked with light gray and white. This is a seam of partially weathered silty shale. Thin chips of sandstone occur between depths of 8 and 26 inches. Below 26 inches is a thick bed of reddish-yellow and brown sandstone. The silty shale at a depth of 22

inches is neutral (pH 7.2). Grass roots penetrate to a depth of 26 inches but turn when they reach the sandstone below.

The thickness of the surface soil varies from 6 to 12 inches; the color ranges from dark grayish brown to dark brown. The substratum contains varying amounts of slightly acid silty and clayey shale, which is gray, brown, and locally reddish brown. In places there are seams that are alkaline. Where Collinsville soils are transitional to the Darnell, the surface soil is less dark and there is a thin zone of brown sandy loam between the surface layer and the sandstone bedrock.

Use and management (unit VIs–1).—Most of the soils in this complex have a cover of native grasses. When the grasses are maintained, these soils have a fairly high carrying capacity for cattle. Woody growth is a pest, particularly on the sandier Collinsville soils. If not controlled, it kills the grass by shading.

The Collinsville soils are particularly invaded by post and blackjack oaks and sumac. The trees start in small clumps but gradually thicken and form a heavy growth. Sumac and persimmon trees invade the Sogn and Talihina soils. They occur mostly in bands below the limestone and sandstone outcrops. Woody plants make the greatest inroads on the heavily grazed pastures.

Pastures should be stocked so that the native grasses can seed themselves each year. Areas should not be burned, as this destroys the surface mulch. Weeds should be mowed on the more level areas; ragweed should be controlled by spraying.

Experiments now in progress may disclose a practical method for control of woody vegetation through use of chemicals.

Stephenville Series

In the Stephenville series are brown to pale-brown, forested soils of medium depth that have developed in weathered soft, brownish to reddish sandstone. They have a very thin, darkened surface soil and a reddish sandy clay subsoil overlying sandstone bedrock. In general these soils resemble those of the Dougherty series, but they have a thinner surface soil and a more compact subsoil and have developed in weathered sandstone instead of in soft sandy loam eolian deposits. They are lighter in color and more shallow than the Bates soils which, in some places, occupy the prairie edges adjacent to the Darnell and Stephenville soils. Only one soil of this series is mapped in the county.

Stephenville fine sandy loam, 2 to 5 percent slopes (Sc).—This soil is of moderate extent in the county. It has a pale-brown surface soil and a yellowish-red subsoil. One-quarter of this soil is on slopes of less than 3 percent, and most of the rest is on slopes of about 4 percent.

This soil occurs on gentle slopes in association with the Darnell soils in the forest-prairie transition of the Cross Timbers belt. It is a deeper soil than the Darnell soils, and it has a developed subsoil that the Darnell lacks (fig. 4).

Typical profile under a cover of bluestem grass in a formerly cultivated area on a slope of 2½ percent (NE¼NE¼SE¼ sec. 20, T. 21 N., R. 8 E.):

0 to 8 inches, pale-brown (10YR 6/3; 4/2.5, moist) fine sandy loam; weak granular structure; very friable; rapidly permeable; slightly acid (pH 6.3); upper inch is slightly darkened, or dark grayish brown (10YR 4/2, moist); layer contains many fine roots; grades to the layer below.

8 to 24 inches, yellowish-red (5YR 5/6; 4/6, moist) sandy clay mottled with 10 percent dark red (2.5YR 4/6) and strong brown (7.5YR 5/6); weak fine subangular blocky; firm; moderately permeable; slightly sticky when wet, hard when dry; slightly acid (pH 6.0); has some brown, fine root channels filled with material from above; a few sandstone fragments occur in lower part; grades to layer below.

24 to 32 inches, mottled red (2.5YR 4/6), yellowish-red (5YR 5/6), and strong-brown (7.5YR 5/6) sandy clay loam interlayered with brown partly weathered sandstone; slightly acid (pH 6.5); rests on bedrock of firm noncalcareous Pennsylvanian sandstone at a depth of 32 inches.

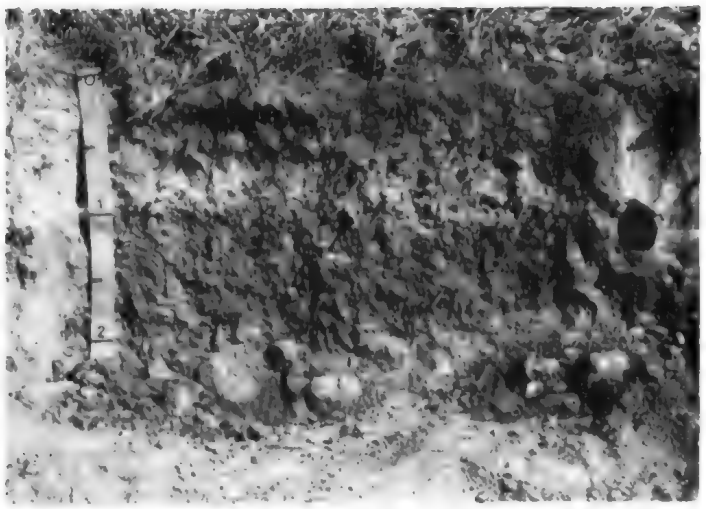

***Figure 4.*—Profile of Stephenville fine sandy loam: Thin, darkened surface soil; light-colored subsurface layer; sandy clay subsoil beginning at a depth of 12 inches; and sandstone below 24 inches.**

The surface soil varies from 8 to 12 inches in thickness. Under native forest vegetation, the upper 3 to 4 inches is normally dark grayish-brown fine sandy loam or loam. The total depth of the soil ranges from 18 to 32 inches or more, but shelf rock may outcrop at the surface in some places. A few small areas of this soil have developed above drainageways on material that has moved down from above. These areas ordinarily are more deeply weathered and have a deeper sandy clay subsoil that extends to depths of 36 to 40 inches.

Nearly one-third of this soil has lost much of its surface layer, and in these areas tillage exposes the reddish subsoil. Such eroded areas also have a number of shallow gullies, some of which cut into the sandstone. Some areas of this Stephenville soil include bodies of pale-brown loam overlying reddish-brown silty or sandy clay. These areas have formed where clay shales are interbedded in the sandstone; they are areas of Windthorst soils, which normally are associated with the Stephenville soil in counties farther south.

The Stephenville soil absorbs water readily. It responds to light rains but has limited storage capacity and is droughty in summer. The slopes are favorable to water absorption. If they are under their native forest, runoff is not rapid. Periods of long cultivation deplete this soil of organic matter. Because of this, the risk of erosion increases and areas begin to gully where the ledge rocks come close to the surface. Once started, erosion is hard to check. Terraces are hard to maintain because soil for fills is scarce.

Use and management (unit IIIe–3).—About 60 percent of this soil has been farmed, but only 25 percent is now cropped; the rest is in some stage of regrassing. The uncleared part has a thin growth of post and blackjack oaks and a thin ground cover of native tall grasses. The cropland is planted mostly to cotton and to sorghums for feed. Rye and wheat are grown to some extent, but yields are low. Muskmelons, sweetpotatoes, and similar crops grow well in moist seasons.

This soil should be kept under vegetation as much of the time as possible. Vetch is a good legume to plow under as green manure or to leave on the surface. If fertilized, a pasture mixture of bermudagrass and lespedeza makes good growth on abandoned fields and produces much more forage than native grasses. Small areas of this soil could be used for small fruits that mature before summer heat and drought set in.

The trees on this soil are seldom good enough to warrant the practice of forestry (fig. 5). If the soil can be cleared, the native grasses will come in naturally. There are some hay meadows on this soil, but it is difficult to keep oak brush from invading them.

***Figure 5.*—Characteristic open forest of post and blackjack oaks on Stephenville fine sandy loam; this is not commercial grade timber.**

Summit Series

Soils of the Summit series have developed under bluestem in material weathered from limestone and soft olive and yellowish-gray shale. Their surface soil is very dark brown or nearly black and strongly granular. The subsoil is dark grayish-brown granular clay that rests on firm, neutral to weakly alkaline clay.

This series occurs only in narrow bands on the slopes below the limestone-capped escarpments that underlie the Sogn soils. Commonly the Summit soils are in bands 100 to 300 feet wide on the limy materials at the base of rocky slopes. Farther down the slope they may be succeeded by the Dennis soils. Only one soil of this series is mapped in the county.

Summit clay loam, 3 to 5 percent slopes (Sd).—This is the least extensive of the dark-colored soils on the prairie uplands. It is mainly in the central part of the county and normally in small bodies that are long and narrow. Slopes range from 3 to 6 percent, but the dominant range is from 3 to 5, and the average slope is 4 percent. In many places this soil is associated with the Dennis soils, which have a browner, less clayey and less granular surface soil. It is more acid and overlies shale and sandstone.

Typical profile 3½ miles southeast of Skedee in a cultivated field on a slope of about 4 percent (NE¼NE¼-SE¼ sec. 6, T. 21 N., R. 6 E.):

0 to 9 inches, dark grayish-brown (2.5Y 3.5/2; 10YR 2/2, moist) clay loam; moderate medium granular structure; friable to firm; permeable; slightly acid (pH 6.3); contains a few small black ferruginous pellets and a few fragments or pebbles of quartz; the lower part below plow depth is strong medium granular; grades to layer below.

9 to 22 inches, grayish-brown (10YR 4/2; 3/2, moist) clay; strong fine subangular blocky; moderately permeable; firm to friable when moist, hard when dry; slightly acid (pH 6.5); exteriors of granules are shiny and slightly darker than interiors; contains some small black ferruginous pellets; 3-inch transition to layer below.

22 to 48 inches+, grayish-brown (10YR 4/2; 3/2, moist) clay streaked with 5 percent yellowish-brown (10YR 5/8, moist) weak medium subangular blocky; very firm when moist, very hard when dry, sticky and plastic when wet; neutral (pH 7.0); lower part of the soil more yellowish and more coarsely blocky and contains a few fragments of soft, yellowish sandstone within a thick zone of clay that is not noticeably stratified; contains some black ferruginous pellets and a few lime concretions; a few fine root hairs penetrate as deep as 48 inches along cracks between the aggregates; this layer is partly weathered clay or weak shale of Pennsylvanian age.

The thickness of the surface soil ranges from 6 to 14 inches; the color, from very dark brown to black. The upper subsoil is locally a heavy silty clay loam and in places is alkaline in reaction. The lower subsoil is alkaline. In many places this soil has developed in material of reddish-brown color and it is browner throughout.

Some areas of this soil on foot slopes below stony soils have been included with Dennis soils because the areas were too small to map separately.

Because this Summit soil is so granular, water is readily absorbed into the surface soil and fairly well in the upper subsoil. The risk of erosion is moderate, so cultivated fields need terracing. Water flowing down from steep slopes causes gullying on this soil. Diversion terraces will head off water before it can reach this soil.

Use and management (unit IIIe–2).—About 25 percent of this soil is cultivated, 33 percent is old cropland now regrassing, and most of the rest is in native pasture and meadow. Less than 10 percent has been eroded to the extent that productivity is lower. A few areas that have a number of rills and shallow gullies and a surface soil only about 5 inches thick were recognized during field mapping. These eroded areas are not shown on the soil map for this report.

The dominant crops are wheat, grain sorghums, corn, cotton, oats, and alfalfa. Yields are good. The stands of alfalfa are apparently productive and long-lived. Phosphate will encourage growth of legumes; lime probably is not needed for all areas but may be required on some. The soil should be terraced, and diversion terraces should be placed on the slopes above it.

Prairie hay meadows appear to be very productive. Because the areas of Summit soil normally lie close to a good source of bluestem grass seed, it is not difficult to regrass the abandoned croplands.

Teller Series

The soils of the Teller series have developed mainly under thin oak forest and a ground cover of bluestem grasses, but many areas contained no trees. The silty to moderately sandy parent material is old alluvium that seems to have been mixed with or overlain by eolian deposits blown up from the flood plains of the major streams.

These soils have a dark-brown friable surface soil, a reddish-brown granular clayey subsoil, and an unconsolidated reddish substratum of slightly acid to neutral reaction. The soils occur on dissected undulating to sloping remnants of the high lying mantled areas.

Teller soils occur in association with the Dougherty soils, which have formed in more sandy deposits and are bleached in the lower part of their surface soil. The Teller soils look much like the Norge, but they have a less clayey subsoil derived from material like that of the Norge soils but younger . On stronger sopes of 5 to 10 percent the Teller soils are closely related to the Vanoss. Vanoss soils have a darker, deeper suface soil than the Teller, and their subsoil is more yellowish and in many places finer in texture. Except for having a more developed profile, the Teller soils resemble those of the Minco series.

The Teller soils of this county vary so much in texture of the surface soil that they have been mapped together as Teller soils, and no texture has been specified.

Teller soils, 2 to 5 percent slopes (To).—These soils are on convex slopes ranging from 1½ to 6 percent, but the average is about 4 percent. About a fifth of the acreage has slopes of 3 percent or less. The soils are on uplands 20 to 70 feet above the flood plains of the major streams. Most commonly they are on the high bench above the second bottoms on low terraces. Some of the areas are 1 to 2 miles back from the flood plains of the Arkansas and Cimarron Rivers. In the eastern part of the county, several areas are higher than 20 to 70 feet above the flood plains of the Arkansas and Cimarron Rivers (fig. 6).

Representative profile 7 miles southeast of Cleveland in a cultivated field on a slope of 3 percent (SE¼SW¼NW¼ sec. 5, T. 20 N., R. 9 E.):

0 to 10 inches, brown (7.5YR 5/3; 4/2, moist) very fine sandy loam; weak granular structure in the upper 6-inch plow layer; moderate medium granular structure below; friable; permeable; slightly acid (pH 6.5); grades to layer below.

10 to 18 inches, reddish-brown (6YR 4.5/3; 3/4, moist) clay loam; moderate medium granular; friable; permeable; slightly acid (pH 6.5); contains numerous pinholes, worm casts, and fine roots; grades to layer below.

18 to 30 inches, yellowish-red (5YR 5/5; 4/5, moist) silty clay loam, slightly heavier than the layer above; moderate medium granular structure; friable; moderately permeable; slightly acid (pH 6.5); pinholes and fibrous roots are numerous; grades to layer below.

30 to 50 inches+, red (3YR 5/5; 4/5, moist) clay loam; weak medium granular structure; friable; permeable; slightly acid (pH 6.2); contains large amounts of very fine sand and is less clayey than layer above; below 42 inches, material is slightly streaked with light brown and other shades of brown.

The surface soil ranges from fine sandy loam to loam or coarse silt loam; and the substratum, from loam to clay loam. In cultivated fields the surface soil is light brown in some places. In some areas under oak forest the undisturbed soil is brown when moist, instead of dark brown.

Figure 6.—**Profile of Teller soils: Deeply permeable; lack strongly developed horizons.**

These soils are highly susceptible to gully erosion. About 20 percent of the acreage has been appreciably eroded. Spots of subsoil are exposed, and there are a number of rills and shallow gullies. The surface soil ranges from 2 to 9 inches thick in eroded areas, and the average is 5 inches.

The soils absorb water readily. The subsoil holds moisture moderately well; it drains well during moist seasons and releases moisture for crops in dry seasons.

Use and management (unit IIIe–1).—About 50 percent of the acreage is cultivated. Less than 33 percent is old fields that are regrassing, and most of the rest is in native tall grasses.

Corn is the dominant crop. Wheat, alfalfa, and cotton are also grown. Under ordinary management, yields for all crops are moderate. Under improved management, which includes terracing and contour cultivation, yields are fairly high. For good yields of alfalfa, phosphate and a little lime are needed. Orchards, small fruits, and special crops do well.

Seeding of Korean lespedeza in old-field pastures will help improve them during the early stages when the grass is thin. Bermudagrass has been used with good results in regrassing old fields.

Teller soils, 5 to 10 percent slopes (Tc).—These soils are of much less extent than the smoother Teller soils, 2 to 5 percent slopes. They occur mainly on the breaks above the river bottoms and along the sides of drainageways. Slopes in these areas range from 5 to more than 10 percent and average about 7 percent.

Erosion has depleted nearly one-third of these soils. In

such areas the surface soil is only 4 or 5 inches thick and there are many rills and shallow gullies. Many of these areas still can be reclaimed. Careful management can make them productive again.

Use and management (unit IVe–2).—About 25 percent of these soils is cultivated, one-half is retired from crops, and the rest has a cover of oaks and tall grasses. The area retired from cropping accounts for nearly all of the eroded acreage.

These soils are too steep for continued use for row crops under ordinary management. Small grains or alfalfa do well without special practices. But if these soils are cultivated, they require a complete, carefully maintained system of terraces.

Apples, plums, and pears do well on these soils. If planted on the contour, the orchards can be cultivated easily; rye and vetch can be grown beneath the trees. Improved pastures of bermudagrass and legumes do well. In places where the soils of old fields are stablilized, tall grasses reseed easily if a seed source is present. The grasses thicken fairly rapidly. For maximum growth of grass, additions of phosphate and nitrogen are needed on old fields. Trees to be used for fence posts grow well on these soils.

Teller and Dougherty soils, severely gullied, 3 to 8 percent slopes (Ta).—These are deep friable soils occurring mostly in the eastern part of the county. They have been severely eroded because their soft, friable substratum gullies easily.

A network of gullies has developed. In places, gullies 5 to 10 feet deep occur at intervals of 100 feet or less. They have steep sides and tend to undercut. As they continue to grow, soil columns drop off from the sides and the gullies gradually widen themselves. These gullied soils are on moderately steep slopes (5 to 7 percent).

These soils occur in many small bodies among larger bodies of Dougherty and Teller soils. Most areas occur at lower edges of long slopes. In places they are located in breaks in the relief where the soil mantle is shallow over a ledge of bedrock. Because much of the surface in these areas is bare or is only thinly covered with grasses, the risk of erosion is high. A typical area of these soils is 7 miles southeast of Cleveland (W½SE¼ sec. 31, T. 21 N., R. 9 E.).

Use and management (unit VIIe–1).—These soils are not suited to continued cultivation. However, at great cost, some areas could be reclaimed for crops. Because of the favorable texture of the subsoil and the substratum and the lack of rocks, power equipment can be used to fill the gullies. A new topsoil will eventually develop in the resulting materials. Such methods are costly, and most farmers prefer to keep these soils in pasture.

A more practical method to stabilize the gullies is by building terraces to divert drainage waters from higher lying lands. Once the water is diverted, the gullies will gradually fill and grass will grow. Because the soil between the gullies will regrass normally, this becomes a seed source for reseeding the gullies.

Bermudagrass and Korean lespedeza will do well on these soils if phosphate is added to increase the fertility. Black locust trees planted in gully heads do well and help stabilize these soils.

Vanoss Series

Soils of the Vanoss series have a deep, granular, dark grayish-brown surface soil, a dark-brown upper subsoil, and a brown, somewhat mottled silty clay loam lower subsoil. The substratum is normally strong-brown to reddish-brown soft clay loam of neutral reaction. The soils formed under bluestem grasses. They occur on gentle slopes that have a weakly concave to weakly convex relief. They overlie silty deposits that came from the flood plains of the major streams. Most typically these soils develop on the benches bordering the Cimarron and Arkansas Rivers. Only one soil of this series is mapped in the county.

Vanoss silt loam, 0 to 2 percent slopes (Va) —This dark grayish-brown soil occurs mostly on the undissected parts of the high benches that extend back from the second bottoms of the rivers. Locally it occupies low terraces that are just above the overflow level on the flood plains of inland streams. In places this soil occurs on flats in close association with the Dougherty soils. About two-fifths of the soil lies on slopes of 1 percent; the rest is on slopes ranging from 1 to 3 percent and averaging about 2 percent (fig. 7).

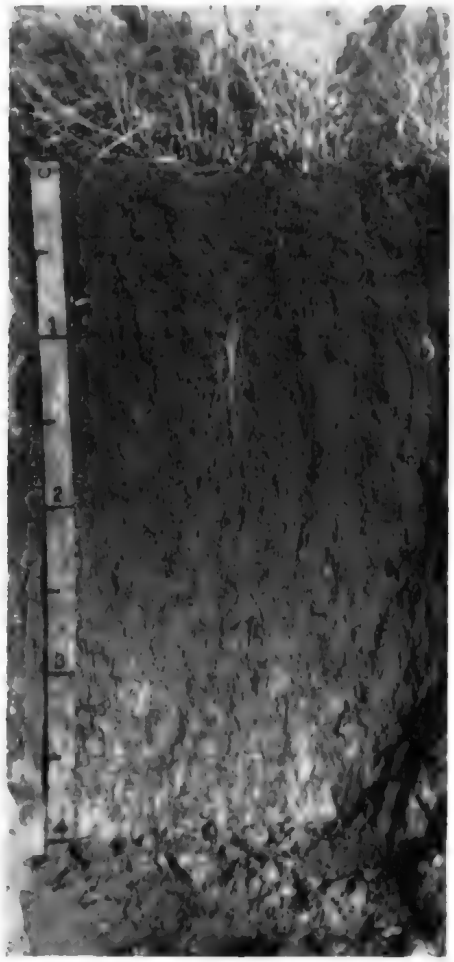

***Figure 7.*—Profile of Vanoss silt loam. This deep, permeable soil becomes lighter in color below about 30 inches.**

Typical profile in a cultivated field on a slope of about 1 percent (SW¼NW¼SW¼ sec. 1, T. 23 N., R. 5 E.):

0 to 14 inches, dark grayish-brown (10YR 4/2; 3/2, moist) silt loam; moderate medium granular structure; friable; soft and crumbly; moderately permeable; slightly acid (pH 6.5); grades to the layer below.

14 to 24 inches, dark-brown (7.5YR 3.5/2; 2.5/2, moist) clay loam; moderate medium granular structure; friable; moderately permeable; slightly acid (pH 6.5); contains many pinholes and worm casts; grades to layer below.

24 to 42 inches, brown (7.5YR 5/3; 4/3, moist) silty clay loam; moderate medium granular structure; friable to firm when moist, moderately hard when dry; moderately permeable; slightly acid (pH 6.0); contains many pinholes and worm casts; 6-inch color transition to layer below.

42 to 84 inches+, reddish-brown (5YR 5/4; 4/4, moist) silty clay loam same as that in layer above; neutral (pH 7.0) at 48 to 80 inches; lower part somewhat more red—reddish brown (5YR 4/4 moist); fine grass roots penetrate through layer and appear to extend to depths of 80 inches or more.

The texture of the surface soil ranges from heavy silt loam to very fine sandy loam. The color of the clay loam upper subsoil varies from dark grayish brown to brown; the thickness, from 6 to 12 inches. The lower subsoil is brown and normally specked or finely mottled with strong brown, but locally it is yellowish brown. The texture of the lower subsoil ranges from clay loam to light silty clay. The underlying substratum is brown, strong-brown, or reddish-brown loam to silty clay loam.

In a number of small areas the subsoil below a depth of 24 inches is a subangular blocky silty clay that is slightly specked or mottled. The profile in these areas resembles that of the Bethany series, not mapped in this county. Because of the small size of these areas, they are included with the Vanoss soil. Other small included areas have a blocky clay subsoil at depths of 12 to 20 inches and are similar to the Kirkland soils. Vanoss resembles the Teller soils. It is darker and browner in the subsoil, however, and occupies smoother, more level areas. This soil occurs with the Norge soils but has a less clayey subsoil and is less sloping.

Erosion is not a serious problem on this soil as it occupies gentle slopes and absorbs most of the rainfall. Around the shallow drainageways moderate amounts of the surface soil have been lost. Terraces are needed if the area is to be cultivated. Except as guides to contour farming, terraces probably are not needed on slopes of 1 and 2 percent. They are required on areas in foot-slope positions.

Use and management (unit I–2).—Vanoss silt loam, 0 to 2 percent slopes, is the most fertile of the upland soils. More than 80 percent is cultivated, and a very small amount has been retired from cultivation. The rest is in native grasses used to some extent for hay. Corn, wheat, alfalfa, cotton, and oats are the principal crops, and yields are good. The soil responds well to management. Because of the favorable moisture-supplying capacity of this soil, fertilizers can by used successfully (fig. 8).

In general, the supply of organic matter is high. Because of continued cropping, many areas have been depleted of the plant nutrients needed to produce optimum yields. If the soil is properly fertilized, good crops of sweetclover and alfalfa can be expected. These legume crops will increase and permanently maintain the fertility of the soil.

Orchards do well. Common pasture plants also do well and produce good yields. Lots planted to trees for fence posts are normally successful.

***Figure 8.*—Field of Vanoss silt loam prepared for winter wheat; Dennis soils in the background.**

Vernon and Lucien Soils

This is a complex mixture of shallow prairie soils that have developed on red clay or shaly clay and on sandstone of the redbeds areas in western Pawnee County. These rocks are mostly thin bedded. Because of this, the kind of rock varies widely in short distances and there are few large, distinct areas of either the Vernon or Lucien soils.

Vernon soils have formed on strong to steep slopes in material from consolidated, calcareous red clay or shaly clay. The Lucien soils occupy sandy ridgetops and areas where sandstone rock outcrops along the sides of drainageways. In general, the Lucien soils are less sloping than the Vernon (fig. 9).

Vernon and Lucien soils, 5 to 15 percent slopes (Vb).—These soils occur mostly in the western third of the county. They occupy sloping to strongly rolling areas. The complex varies widely in composition. In areas where the Renfrow and Kirkland soils are dominant, there is more Vernon soil in the complex (fig. 10). Where the Zaneis soil is dominant, the proportion of Lucien soil in the complex is greater. A large part of the Lucien soil occurs on the sandy ridgetops on only moderate slopes. Oaks have invaded many of these areas.

By average percentages, the complex is 55 percent Vernon soil, 40 percent Lucien, and 5 percent Zaneis and Renfrow. The Zaneis and Renfrow occur mainly on the

***Figure 9.*—Vernon and Lucien soils in western Pawnee County. The sandy Lucien soils have a thin cover of blackjack oaks.**

Figure 10.—Narrow area of Vernon clay loam in center area; Renfrow soil in background above the rim of broken land.

more gentle slopes but for the most part are not suited to cultivation because their position is not favorable.

The Vernon soil has a granular, dark-brown surface layer that is alkaline or calcareous. The subsoil is reddish-brown clay overlying reddish-brown to dusky-red, calcareous clayey material at shallow depths. The Vernon soil resembles the Renfrow soils, occurs in association with them, but it occupies the strongly sloping drainage sides and the escarpment areas. The dominant slope range for the Vernon soil is 5 to 15 percent, but the slope exceeds this in a few areas. On the surface the Vernon soil resembles the Renfrow, but the Vernon soil occupies steeper slopes, is much more shallow, and is so slightly developed that it is much like the rock material from which it was derived. The Vernon soil is much redder than the Kirkland soil that in some places occurs in association with it. The Vernon soil is much more clayey than the Lucien, which overlies sandstone and has a sandy friable surface soil and subsoil. Normally the Vernon soil occupies steeper slopes than the Lucien and has more spots and gullies on which there is no vegetation. Drainage is rapid from the surface and slow through the soil.

Typical profile of Vernon clay loam 6½ miles southwest of Pawnee under native gramas, buffalograss, and tall grasses on a slope of 10 percent (NE¼SE¼NE¼ sec. 34, T. 21 N., R. 4 E.):

0 to 5 inches, dark-brown (7.5YR 4/2; 3/2, moist) clay loam; moderate medium granular structure; friable; neutral (pH 7.0); abrupt transition to layer below.

5 to 10 inches, dark reddish-brown (5YR 4/4; 3/4, moist) clay; moderate fine subangular blocky structure; firm; sticky and plastic when wet; mildly alkaline (pH 7.5); grades to the layer below.

10 to 30 inches +, weak-red (2.5YR 5/2; 4/2, moist) calcareous shiny clay containing many lime concretions; layer is slightly shaly in the lower part and contains lenses of sandy material that are only slightly altered redbed rocks.

The Vernon soil varies chiefly in kind and color of the underlying rocks. The rocks are dominantly red, but there are layers of brown, grayish brown, and olive clay and, in places, of brown sandstone. At the tops of a few escarpments there are fairly thick ledges of pinkish limestone underlain by red clay. In some transitional areas the Sogn and Vernon soils are intermixed. On steep drainage sides the Vernon is mixed with the Lucien soil. In these places the Lucien, which developed on interbedded sandstone, may account for as much as 20 percent of some areas.

The Lucien is a dark reddish-brown or dark-brown shallow soil that has a red or reddish-brown substratum of soft sandstone. Locally the substratum contains seams of clay. The Lucien soil resembles the Darnell soils but has developed under a cover of bluestems, has a darker surface soil, and has no bleached lower layers. The Lucien soil is like the upper part of the Zaneis soils and is associated with them. But the Lucien soil is much shallower and less developed. The Lucien soil occupies the sandstone-capped ridgetops and the sloping drainage sides in the part of the county dominated by the Zaneis soils.

The native vegetation on the Lucien soil was largely tall grasses. Many overgrazed areas are now being invaded by post and blackjack oaks. After it has been under this oak cover for many years, the surface soil loses some of its darkness, and the profile becomes much like that of the closely related Darnell soil.

At the site of the typical profile that follows, the cover is an unplowed pasture consisting of a thin stand of little bluestem, silver broadgrass, three-awn, ragweed, and broomweed overtopped by oak clumps and sumac patches. The surface is free of stones, but a band of sandstone ledges outcrops nearby. Drainage is rapid from the surface and through the soil.

Typical profile about 5 miles southwest of Pawnee in an undisturbed pasture on a slope of 3 percent (NE¼NE¼ NW¼ sec. 21, T. 21 N., R. 4 E.):

0 to 5 inches, reddish-brown (4YR 4/4; 5YR 3/4, moist) fine sandy loam; weak granular structure; very friable; rapidly permeable; medium acid (pH 5.5); grades to layer below.

5 to 15 inches, reddish-brown (2.5YR 4/3; 3/4, moist) sandy clay loam containing seams of weakly compacted sandstone and seams of sandy shale that are only slightly weathered, medium acid (pH 5.5); grass roots penetrate freely into this layer; grades to layer below.

15 to 24 inches+, reddish-brown (2.5YR 5/4; 3/3, moist) weakly indurated sandstone containing lenses of fine sandy loam and seams of sandy clay shale; medium acid (pH 6.0); lower material is somewhat redder; seam of much harder sandstone occurs at 22 inches and appears to stop penetration of fine roots of both grass and trees.

The surface soil ranges from 3 to 6 inches in thickness, and the total depth of the soil to bedrock is 3 to 20 inches. The texture of the surface soil ranges from fine sandy loam to loam. The color of the surface soil varies from dark brown to dark reddish brown. In a few areas adjacent to outcropping ledges, flags of sandstone occur on the surface. The outcrops occupy nearly 15 percent of some areas. The Lucien soil is closely associated with areas of sloping and strongly sloping Zaneis fine sandy loam and Vernon clay loam. The latter has developed on included areas of soft reddish clay.

Use and management (unit VIs–1).—Soils in this complex are used entirely for pasture. When grass is good, these areas have a fairly high carrying capacity for cattle. Many areas have been invaded by oak, sumac, and persimmon trees. This seriously lowers the value for grazing.

The Lucien soil absorbs water readily but does not have a large storage capacity. Much water enters the underground stratum and is lost to vegetation. Because of this, the vegetation often is subject to drought in dry seasons.

In the areas of Lucien soil many overgrazed areas that are free of oaks can be renovated and planted to native

grasses or to mixtures of bermudagrass and Korean lespedeza. Bare spots in the Vernon areas can be planted to native grasses. A good method is to use a seed-hay mulch.

Yahola Series

In the Yahola series are alluvial soils that have a brown, friable surface layer and a reddish-brown to yellowish-red substratum of sandy loam. Other shades of brown occur as distinct layers in the subsoil.

These soils occur along the low flood plains of the Arkansas and Cimarron Rivers. In places they occupy narrow areas in the flood plains of Black Bear and Camp Creeks. They are neutral to alkaline and have developed in alkaline to calcareous sediments of recent origin. These sediments originated from mixed Permian "Red Beds" and Tertiary deposits on the high plains to the west. The soils are most reddish in the flood plains of the Cimarron River, Black Bear Creek, and in areas along the Arkansas River lying below the mouths of the Red Rock and Black Bear Creeks. In general, the sandier types in this series are lighter in color and have lenses of loamy fine sand in the substratum.

The Yahola soils occur in association with the Miller soils, which occupy old backwater areas and filled swales, mostly on the inland sides of the flood plains. The Yahola soils are associated with Sandy alluvial land along the river channels and with Mixed alluvial land along Black Bear and Camp Creeks. The Dale soils, which are on the bench lying 6 to 8 feet above the Yahola soils, are much darker throughout. Also associated with the Yahola soils are the Port soils which are darker, finer textured, and do not have a sandy substratum.

Yahola silt loam (Ya).—This soil occurs on the nearly level areas of the flood plains lying toward the upland side of the bottoms. It occupies slopes of 0 to 1 percent. It has a dark-brown, friable, slightly wavy surface layer.

A representative profile on the flood plains of the Arkansas River on a level area about 1 mile southeast of Cleveland (SE¼SE¼SE¼ sec. 16, T. 21 N., R. 8 E.):

0 to 14 inches, dark-brown (7.5YR 4/2; 3/2, moist) silt loam; weak granular structure; friable; permeable; weak horizontal breakage; material somewhat streaked with light brown; neutral (pH 7.0); indistinct transition to layer below.

14 to 26 inches, reddish-brown (6YR 5/3; 4/2, moist) silt loam; weak granular to massive structure; slightly stratified with brown very fine sandy loam; neutral (pH 7.2).

26 to 60 inches, light reddish-brown (5YR 6/4; 5/4, moist) very fine sandy loam stratified with silt loam and with reddish-yellow (5YR 6/6; 5/4, moist) fine sandy loam; massive; very friable; rapidly permeable; moderately alkaline (pH 8.0) but noncalcareous; lower part banded with light-brown (7.5YR 6/3) fine sandy loam.

The texture of the surface layer varies from heavy silt loam to very fine sandy loam, and the color, from dark brown to reddish brown. The surface soil is mostly neutral or mildly alkaline but locally it is calcareous. Below the surface layer the material is brown to reddish brown fine sandy loam to light silt loam. In many places it is banded with clay loam and loamy sand. Below 36 to 48 inches the material is commonly sandier, browner, and more permeable.

A few narrow swales are normally occupied by more clayey soils that have a clay loam surface soil and upper substratum. In some areas along the Arkansas River are soils that have a brown or grayish-brown surface soil and a light-brown subsoil. These areas are of the Arkansas series—not mapped in the county—and, except in color, are much like the Yahola soils. Even in these browner areas, however, the substratum has bands of reddish brown in many places.

Although Yahola silt loam absorbs water readily and drains quickly after rains, it retains enough moisture for good growth of crops. Water tables normally lie at depths of 10 to 18 feet, but deep-rooted crops may benefit from this water.

Use and management (unit I–1).—More than 90 percent of this soil is cultivated. A few irregularly shaped areas are used for pasture. Many areas have thick growths of American elm, cottonwood, sycamore, black walnut, hackberry, pecan, and white and red oaks, as well as some silver maple, redcedar, and willow. Beneath the forest are redbud, chittamwood, buttonbush, and many vines and scattered bunches of grass. A number of small pecan groves remain. Johnsongrass is a serious pest on the cropland.

Corn, wheat, cotton, oats, and alfalfa are the main crops. Yields are very good. Corn and cotton crops are seldom completely destroyed by floods, but flooding sometimes damages the grain just before harvest. Flooded fields are sometimes replanted to grain sorghums, which can be harvested for grain or for bundle feed.

This soil responds well to management. Areas that have been in row crops continuously are producing at only about two-thirds of their capacity at present. Improved pastures of bermudagrass overseeded with clovers can be grazed heavily through a long season.

Small irregularly shaped fields can well be used for catalpa or black locust. These trees grow fast and can be used for fence posts.

Yahola fine sandy loam (Yb).—This reddish-brown friable soil is on the very slightly wavy areas of bottom land that lie back of the stream channels on natural dikes several hundred feet wide. Normally it lies 1 to 4 feet higher than Yahola silt loam, which is on the more nearly level areas on the inward side of the bottom lands.

In periods of high water the dikes sometimes prevent flooding of the bottom lands. In places the dikes may be above water while lands to the rear are covered. The dikes have good surface drainage because of their slope. They can be worked very soon after a thorough wetting.

Typical profile about 3 miles northwest of Keystone on bottom land along the Cimarron River on a slope of about 1 percent (SE¼NW¼NW¼ sec. 27, T. 20 N., R. 9 E.):

0 to 14 inches, reddish-brown (5YR 5/4; 4/3, moist) fine sandy loam; weak granular structure; friable, in lower part weakly stratified with reddish-brown very fine sandy loam; distinct horizontal cleavage; mildly alkaline (pH 7.5); indistinct transition to layer below.

14 to 44 inches, reddish-yellow (5YR 6/5; 5/5, moist) light fine sandy loam; very friable; rapidly permeable; neutral (pH 7.0); stratified with light-reddish brown (5YR 6/4; 5/4, moist) very fine sandy loam.

44 to 60 inches, pink (5YR 8/4; 7/4, moist) loamy very fine sand to fine sand; very friable and very rapidly permeable; neutral (pH 7.0).

The color of the surface soil ranges from light brown to reddish brown, and the thickness, from 8 to 20 inches. The texture varies from very fine sandy loam to loamy fine sand and is coarsest on the tops of the very gentle

ridges. The reaction varies from neutral to alkaline, but in places it is calcareous.

The substratum varies in the thickness and arrangement of the layers. In many places it contains 6- to 12-inch lenses of loamy fine sand and erratic layers of silt loam and clay loam. The sandy layers are light brown; the silty ones are dark brown or reddish brown.

About 15 percent of this soil occurs on areas having a distinctly wavy surface and ridges parallel to the stream channel. Surface gradients are as much as 4 percent on the sides of the ridges. Such wavy areas contain narrow swales that have a loamy surface soil and an erratic but more clayey substratum.

A few small areas mapped with this soil have a brown loamy sand surface layer and substratum. These inclusions of Lincoln soils are not mapped separately in this county.

This Yahola soil absorbs water very readily and drains freely. In dry seasons it is droughty for all except the deep-rooted crops that can reach the moist area near the water table.

Use and management (unit I–1).—About 75 percent of this soil is cultivated, a little more than 12 percent is in pasture, and the rest is in native bottom-land hardwoods. Many small native pecan groves remain. Johnsongrass is a serious pest in cultivated fields but is valuable for grazing.

This soil is only moderately productive. Corn yields are not very high. Small grains and cotton appear to do better than corn. In most years grain sorghums are probably better suited than corn. Alfalfa does well and could be used more widely, as it produces fair yields of hay.

When moisture is available this soil responds well to fertilization. Tests made with corn that had been irrigated and well fertilized showed constant high yields over a period of years. Because this soil is low in organic matter, a rotation including legumes is needed.

Improved pastures, such as bermudagrass overseeded with legumes, do very well. Small irregularly shaped fields should be planted to catalpa and black locust, to be used for fence posts. These trees grow fast on this alluvial soil.

Zaneis Series

Soils of the Zaneis series have developed under grass from materials weathered from the sandy strata in the red beds. They have a reddish-brown to brown, slightly acid surface soil, a granular upper subsoil, and a granular clay loam to light clay lower subsoil.

These soils are located in the western part of the county. They are more sandy and have a less dense subsoil than the Renfrow soils, which develop on more clayey areas of the red beds. The Zaneis soils occur in association with the Lucien soils, but the latter are thin soils on sloping areas that overlie sandstone. The Zaneis soils resemble the Bates soils of the eastern part of the county but are much more reddish in the surface soil and have a slightly firmer subsoil. The Zaneis soils also resemble the Dennis soils but are more reddish and normally have a more granular and permeable subsoil than the Dennis.

Zaneis soils, 2 to 5 percent slopes (Za).—These soils occur in fairly large bodies on the ridge crests and the gently rolling slopes below them. About one-tenth of the acreage is on slopes of less than 3 percent; the rest is on slopes averaging between 4 and 4½ percent and ranging up to 5 percent in some places. Drainage is good, surface runoff is rapid, and internal drainage is medium. The hazard of erosion ranges from moderate to severe.

In about 15 percent of the acreage, the surface soil has been thinned by erosion and cut by many shallow rills and a few shallow gullies. These eroded areas occur mainly around the heads of natural drainageways and on the slopes above. In such areas the surface soil ranges from 2 to 8 inches in thickness and averages about 5 inches. Fragments of weathered sandstone occur on the surface near the rills and gullies. These eroded areas were marked on the field sheets, but not on the soil map.

The following describes a typical profile, which is on a low convex hill overlying sandstone and sandy shale, has a slope of 3½ percent, and is surrounded by more clayey beds that are overlain by Renfrow soils (NE¼SW¼SW¼ sec. 9, T. 21 N., R. 4 E.):

0 to 10 inches, reddish-brown (5YR 4/3; 3/3, moist) heavy fine sandy loam or loam; weak granular structure; friable; permeable; slightly acid (pH 6.0); grades to the layer below.
10 to 18 inches, reddish-brown (5YR 4/3; 3/3, moist) light sandy clay loam; moderate medium granular structure; permeable; slightly acid (pH 6.0); grades to the layer below.
18 to 34 inches, red (2.5YR 4/5; 3/5, moist) clay loam; moderate medium granular structure; friable; moderately permeable; slightly acid (pH 6.0); contains a few black ferruginous concretions and a few small fragments of reddish-brown sandstone; grades to substratum.
34 to 40 inches, reddish-brown (2.5YR 4/4; 3/4, moist) sandy clay loam that has thin layers of weakly compacted reddish-brown to dusky-red (2.5YR 4/2) sandstone and sandy shale; slightly acid (pH 6.3); this layer is only slightly weathered material of the redbeds formation.

The surface soil ranges from fine sandy loam to loam and from dark brown to reddish brown. It is mostly reddish in cultivated areas. The lower subsoil varies from sandy clay loam to granular sandy clay or silty clay. The total depth of the profile ranges from 22 to about 48 inches. The soils are deepest where they have developed in colluvial materials on slopes below the thin sandy soils of the ridges and escarpments.

In some upland areas these Zaneis soils have slopes ranging from 2 to 8 percent. The steepest areas generally have shallower soils that are similar to Lucien soils. In some places soils of darker color occur on the broad, gently sloping ridgetops in association with the Zaneis soils. These are inclusions of Chickasha soils too small to map separately.

Use and management (unit IIIe–2).—About 25 percent of the acreage is cropped, 20 percent is abandoned cropland going back to grass, and the rest is in native pasture and meadow. Much of the abandoned land is on the eroded areas.

These soils are moderately productive for the general crops of the area. They are better suited to summer-growing crops than the associated Renfrow and Kirkland soils.

Small grains, grain sorghums, cotton, and corn are the principal crops. These soils respond well to additions of phosphate. If there is to be continuous cropping, terraces are needed on all slopes of more than 2 percent. Fields lying below foot slopes need diversion ditches above them to divert the overhead water.

Grazing should be controlled in pastures so that the tall grasses can reseed annually. Old fields can be improved by introducing native grasses or bermudagrass. The eroded areas of these soils are better suited to permanent grasses than to crops; however, it is harder to establish the stands, and more fertilizers are needed than on the uneroded areas.

Zaneis soils, severely eroded, 3 to 8 percent slopes (Zb).—These soils are severely sheet and gully eroded. Normally the gullying is more noticeable than the sheet erosion. The gullies are deep, 10 to 15 feet wide, and spaced about 100 feet apart. Between gullies the soil appears nearly normal and has 6 to 8 inches of surface layer; but shallow rills are evident here too. In places a few galled areas occur on the side slopes above the gullies. The gullies have cut down to resistant sandstone in places. In many places fragments of sandstone lie on the surface. Many areas underlain by red clay are included with the Zaneis soils; these are severely eroded Renfrow soils.

These severely eroded Zaneis soils occur principally in small areas lying at the heads of drainageways. A typical area is located near Pawnee. In places these eroded soils are within larger areas of moderately eroded Zaneis soils. Normally these eroded soils are located on slopes of 4 to 6 percent. Because of the exposed soil on the sides of gullies and in galled areas, the risk of erosion is high. Unless vegetation is established, these areas deteriorate rapidly.

Use and management (unit VIIe–1).—These soils are not suited to further cultivation, because they are gullied. Grazing is their only use. Normally the stand of grass is thin unless the areas have been regrassing for long periods. However, these soils seem to get a grass cover more quickly than the severely eroded Renfrow soils. It is good practice to divert the water on slopes above so that the gullies on these soils can become stabilized. Grazing should be controlled to allow the tall grasses to reseed each year. To assure the growth and spread of grass on these depleted soils, additions of nitrogen and phosphate are needed.

Use and Management of Soils

This section has four main parts. The first explains how soils are grouped according to their capability. The second suggests some general practices desirable in managing cropland, pasture, woodland, and wildlife areas. Following this general information, there is a description of the 14 capability units, or groups of soils, that need similar management. The third part provides estimated yields of principal crops under two levels of management, and the fourth section discusses management of rangeland.

Capability Groups

Capability grouping is a system of classification used to show the relative suitability of soils for crops, grazing, forestry, and wildlife. It is a practical grouping based on the needs, limitations, and risks of damage to the soils, and also their response to management. There are three levels above the mapping unit in the grouping—unit, subclass, and class.

The capability unit, sometimes called a management group, is the lowest level of grouping. A capability unit is made up of soils similar in kind of management they need, in risk of damage, and in general suitability for use.

The next broader grouping, the subclass, is used to indicate the dominant kind of limitation. The letter symbol "e" indicates that the main limiting factor is risk of erosion if the plant cover is not maintained; "w" means excess water that retards plant growth or interferes with cultivation; and "s" shows that the soils are shallow, droughty, or unusually low in fertility.

The broadest grouping, the land class, is identified by Roman numerals. All the soils in one class have limitations and management problems of about the same degree, but of different kinds, as shown by the subclass. All the land classes except class I may have one or more subclasses.

In classes I, II, and III are soils that are suitable for annual or periodic cultivation of annual or short-lived crops.

Class I soils are those that have the widest range of use and the least risk of damage. They are level, or nearly level, productive, well drained, and easy to work. They can be cultivated with almost no risk of erosion and will remain productive if managed with normal care.

Class II soils can be cultivated regularly but do not have quite so wide a range of suitability as class I soils. Some class II soils are gently sloping; consequently, they need moderate care to prevent erosion. Other soils in class II may be slightly droughty or slightly wet, or somewhat limited in depth.

Class III soils can be cropped regularly but have a narrower range of use. These need even more careful management.

In class IV are soils that should be cultivated only occasionally or only under very careful management.

In classes V, VI, and VII are soils that normally should not be cultivated for annual or short-lived crops, but they can be used for pasture and range, as woodland, or for wildlife.

Class V soils are nearly level and gently sloping but are droughty, wet, low in fertility, or otherwise unsuitable for cultivation.

Class VI soils are not suitable for crops because they are steep or droughty or otherwise limited, but they give fair yields of forage or forest products. Some soils in class VI can, without damage, be cultivated enough so that fruit trees or forest trees can be set out or pasture crops seeded.

Class VII soils provide only poor to fair yields of forage or forest products.

In class VIII, (none in Pawnee County) are soils that have practically no agricultural use. Some of them have value as watersheds, wildlife habitats, or for scenery.

The soils of Pawnee County have been grouped into the following classes, subclasses, and units:

Class I.—Deep, nearly level, productive soils. Suitable for intensive cultivation without special practices other than those normally used for good farming.
- Unit:
  - I–1: Deep, fertile soils that are easy to work and subject to occasional overflow.
  - I–2: Deep, fertile, friable to somewhat cloddy soils of the high bottoms and level uplands.

Class II.—Soils suited to tilled crops, pasture, and trees but have moderate limitations when tilled.
- Subclass IIw: Soils slightly wet or subject to occasional standing water.
  - Unit:
    - IIw–1: Deep, fertile but cloddy soils of the bottom lands that are seasonally wet and hard to till.

Subclass IIs: Soils that are limited by poor texture and unfavorable structure in some part of the rooting zone.
Unit:
IIs–1: Deep, fertile but cloddy soils of benches above overflow; contain occasional slick spots.

Class III.—Soils suited to tilled crops, pasture, and trees but have moderately severe limitations when tilled.
Subclass IIIe: Soils on moderate slopes subject to erosion.
Unit:
IIIe–1: Deep, easily worked, permeable, responsive prairie soils.
IIIe–2: Deep, friable to cloddy, moderately responsive prairie soils.
IIIe–3: Sandy, easily worked, responsive soils that have permeable and freely permeable subsoils; low in organic matter.
Subclass IIIs: Soils that have unfavorable texture or structure in some part of the rooting zone.
Unit:
IIIs–1: Deep, very slowly permeable claypan soils of level and gently sloping prairies.

Class IV.—Soils suited to grass and trees, but, if tilled, suitable for only limited or occasional cultivation and with severe limitations.
Subclass IVe: Sloping and strongly sloping erodible soils that are otherwise favorable for cultivation.
Unit:
IVe–1: Sloping, very slowly permeable and slowly permeable prairie soils that have clay subsoil.
IVe–2: Strongly sloping, permeable, responsive soils that gully readily.

Class V.—Level or nearly level soils not suitable for cultivation because of excess water but having no outstanding limitations if used for pasture or woods.
Subclass Vw: Soils subject to poor drainage or frequent flooding.
Unit:
Vw–1: Dissected and hummocky bottom-land soils locally subject to frequent overflow.

Class VI.—Soils suitable for pasture or trees but not suitable for cultivation because of steep slopes, shallowness, or other limitations.
Subclass VIs: Soils very limited by shallow depth, droughtiness, strong slope, or some other feature more important than erosion.
Unit:
VIs–1: Slightly developed, shallow or stony prairie soils on strong slopes.
VIs–2: Slightly developed, shallow or stony wooded soils on moderate and strong slopes.

Class VII.—Soils not suitable for cultivation and severely limited if used for pasture or trees.
Subclass VIIe: Severely eroded soils.
Unit:
VIIe–1: Severely eroded sloping prairie soils, most of them gullied.
Subclass VIIs: Soils extremely limited by shallow depth, steep slope, stoniness or other factor more important than erosion.
Unit:
VIIs–1: Strongly sloping deep and shallow wooded soils too steep or too rocky for crops.

Management by Capability Units

The soils in a capability unit have many features in common and have about the same limitations and similar risks of damage. The soils in each unit therefore need about the same kind of management, although they may have formed from different parent materials in different ways.

In the following pages each of the 15 capability units in the county is described and suitable management is suggested. Preceding the discussion of the units are some rules of good management that apply to all the soils, whatever unit they are in, if they are used as cropland, for tame pasture, as woodland, or as wildlife habitats. The desired management for any soil therefore consists of these general practices and, in addition, those special practices given for the capability unit in which it has been placed.

Cropland.—Lime and fertilize soils according to needs shown by soil tests and field trials. Use crop residues and manures to supply organic matter and to improve soil tilth. Legumes used in the rotation will add nitrogen and provide plant residues.

Dispose of excess water with waterways of adequate capacity. Maintain them in a way that will keep them operating efficiently. Terrace croplands that have slopes of 2 to 6 percent or more. Slopes less than 2 percent but more than 400 feet long should also be terraced if crops are grown. All tillage should be parallel to the terraces. If fields having slopes of less than 2 percent are not terraced, use contour tillage and stripcropping to control water erosion. A winter cover crop or a stubble mulch will help prevent wind erosion.

Use cropping systems that will aid in maintaining a fairly large supply of organic matter and reasonably high fertility. As a general rule, grow annual legumes every third or fourth year, or alfalfa as often as feasible, or use adequate amounts of fertilizer or other crop residues. A row crop should not follow a row crop, unless fertility requirements are met and erosion control is adequate. Use a rotation of small grains and legumes on sandy or eroded soils. Use winter cover crops on sandy soils to add organic matter and to check wind erosion.

Tame pasture.—Lime and fertilize according to needs shown by soil tests. For best results sow bermudagrass, fescue, or bromegrass with legumes. Weeping lovegrass and sericea lespedeza also produce good pasture, especially on sandy soils. Control grazing to maintain a good cover of grasses and legumes. On some soils small grain-vetch winter pastures may produce more and better forage than the summer pasture grasses.

Woodland.—The woodlands of Pawnee County will produce better posts and timber if good management is practiced. Remove undesirable species and poor-quality trees from existing stands. If the stand is still too heavy, continue thinning until the remaining trees will have a chance to grow to good size. When harvesting, select only those trees that make the best saw logs. Give the small trees that will make good timber enough time to mature. Protect the trees from fire and grazing. Replant open areas where necessary.

Trees of commercial value growing on the lowlands and deep mantle soils include red oak (*Quercus rubra*), black oak (*Quercus velutina*), cottonwood (*Populus deltoides Virginiana*), hackberry (*Celtis occidentalis*), white oak (*Quercus lyrata*), ash (*Fraxinus* spp.) and pecan (*Carya pecan*).

The forest on the uplands consists mainly of blackjack oak (*Quercus marilandica*), post oak (*Quercus stellata*), elm (*Ulmus* spp.) and hickory (*Hicoria alba*). These trees are not suitable for most commercial uses but will produce some fence posts, firewood, and rough lumber.

Wildlife habitats.—Land properly used and managed for other purposes will also provide some food and shelter to wildlife. Turnrows and odd areas can be used as wildlife habitats. Plant them to evergreens trees suitable for posts, shrubs, grasses, legumes, or aquatic plants. Protect these areas from burning and overgrazing. Information on management of wildlife habitats can be obtained from your county agent or the local representative of the Soil Conservation Service.

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CAPABILITY UNIT I-1

Deep, fertile soils that are easy to work and subject to occasional overflow

This capability unit consists of silty and loamy soils. They are on nearly level bottom lands. Flooding ordinarily does not damage row crops, but in some years small grains are damaged by floods that occur near harvesttime. The soils are friable and easy to work. They have a moderate to high moisture-supplying capacity but are too dry during parts of some years. The mapping units are:

Cleora fine sandy loam.
Port silt loam.
Yahola silt loam.
Yahola fine sandy loam.

These soils are well suited to all crops grown in the county, and especially to corn, cotton, and alfalfa. Bermudagrass, overseeded with hop clover, lespedeza, or vetch, makes a productive pasture. Follow a cropping system that regularly supplies organic matter. Grow a legume at least 1 year in 4, or apply crop residues. Protect the soils against runoff water from adjacent higher lands. Irrigate to get good yields in dry years. These soils are good sites for post lot plantings.

CAPABILITY UNIT I-2

Deep, fertile, friable to somewhat cloddy soils of the high bottoms and level uplands

These dark silt loam or silty clay loam soils are on nearly level high bottoms or uplands that are above ordinary overflows. They are well drained to moderately well drained and moderately permeable to slowly permeable. They have a high moisture-supplying capacity. Although originally of high fertility, some of these soils require fertilizer for good yields. The mapping units are:

Brewer silty clay loam.
Dale silt loam.
Vanoss silt loam, 0 to 2 percent slopes.

These soils are well suited to all the crops ordinarily grown in the county. They are especially suitable for corn, small grains, cotton, and alfalfa. Protect soils of this capability unit from runoff from higher adjacent areas by diversion terraces. Grow a legume at least 1 year in 4, or apply crop residues. Irrigate to get good yields in dry years. These soils made good sites for post lot plantings.

CAPABILITY UNIT IIw-1

Deep, fertile but cloddy soils of the bottom lands that are seasonally wet and hard to till

These dark-brown to reddish-brown soils have silty clay loam or clay surface soils. They drain slowly to very slowly and are slowly permeable. They are fertile and have adequate organic matter, but in some years they are too wet to work until late in spring. They are occasionally overflowed, and water sometimes stands long enough to damage crops. The soils are somewhat hard to till because of their fine texture. The mapping units are:

Lela soils.
Miller clay

These soils are moderately well suited to small grains and grasses, but the grains may be damaged by flooding when they near maturity. Corn and alfalfa do fairly well, though in some seasons they are damaged by standing water. Bermudagrass, overseeded with whiteclovers and Korean lespedeza, makes good pasture. A good forage mixture is fescue overseeded with annual legumes, or alfalfa can be seeded with bromegrass.

CAPABILITY UNIT IIs-1

Deep, fertile but cloddy soils of benches above overflow; contain occasional slick spots

In this capability unit is the Brewer-Drummond complex.

The Brewer soils are dark colored and occur on nearly level to slightly convex areas. Within the larger areas of Brewer soils are circular or oval spots of Drummond soils that comprise 15 to 30 percent of the areas.

The Drummond soils have a light-colored silty surface layer that rapidly crusts or puddles after a seedbed is prepared. Their subsoil is a compact dark-brown, silty clay loam to silty clay. The Drummond soils have a low moisture-supplying capacity, and plants are damaged even by short droughts in spring and summer.

The Brewer soils, in contrast to the Drummond, have a high capacity for supplying moisture for plants. Alfalfa, corn, cotton, and small grains do well on the Brewer soils. In most years, corn and cotton on the Drummond soils are damaged by drought. The Drummond soils are better suited to small grains and pasture than to alfalfa or row crops.

For this complex of Brewer and Drummond soils, use a rotation that includes a limited proportion of row crops and is made up mostly of small grains and legumes. Some landowners like to use alfalfa much of the time. Use diversion terraces to protect places that receive excess water from higher areas.

CAPABILITY UNIT IIIe-1

Deep, easily worked, permeable, responsive prairie soils

These soils formed on moderate slopes from materials laid down by wind or water in areas that border the major streams but lie well above them. The surface layers of these soils are dark brown and friable, and the subsoils are reddish brown and slowly to moderately permeable. These soils are well drained and have good capacity for holding moisture for plants. They are of moderate fertility, except that they are low in phosphorus and organic matter. These soils are subject to erosion when tilled. The mapping units are:

Norge fine sandy loam, 2 to 5 percent slopes.
Norge silt loam, 2 to 5 percent slopes.
Teller soils, 2 to 5 percent slopes.

The soils of this capability unit are well suited to small grains, alfalfa, cotton, and grain sorghums. They are moderately well suited to corn. Terracing and contour farming are needed to control erosion when they are tilled. Use a cropping system that contains a legume 1 year in every 3. Pastures can be improved by seeding bermudagrass with winter clovers, vetch, and Korean lespedeza. Fescue pastures may be overseeded with annual legumes, or alfalfa with bromegrass. These soils make fair sites for post lot plantings.

CAPABILITY UNIT IIIe-2

Deep, friable to cloddy, moderately responsive prairie soils

These dark soils formed on moderate slopes from thinly banded shales and sandstone, from calcareous clay shales,

or from sandy redbeds. The surface-soil texture of the soils formed from sandstone and sandy redbeds is a fine sandy loam or loam. Those formed from shales have a silt loam surface texture; those from calcareous clay shales, a clay loam texture. The soils of this capability unit are slowly to moderately permeable and have moderate to high moisture-supplying capacity. They are of moderate to high fertility. All are subject to sheet and gully erosion when tilled. The mapping units are:

Bates fine sandy loam, 2 to 5 percent slopes.
Dennis loam, 2 to 5 percent slopes.
Summit clay loam, 3 to 5 percent slopes.
Zaneis soils, 2 to 5 percent slopes.

These soils are well suited to small grains, grain sorghums, and cotton. A suitable mixture for tame pasture is bermudagrass overseeded with winter clovers or vetch and Korean lespedeza. Alfalfa grows well on all except the Bates soil. Winter pastures of small grains and vetch are often very productive. Where needed, use terraces, grassed waterways, and contour farming to control erosion.

CAPABILITY UNIT IIIe-3

Sandy, easily worked, responsive soils that have permeable and freely permeable subsoils; low in organic matter

These soils, except for Stephenville, have formed on nearly level or moderate slopes from materials laid down by wind or water. The Stephenville soil formed on smooth areas over sandstones. All these soils are low in organic matter and moderately low in fertility. The Minco, Eufaula, and Dougherty soils take water well and have deep storage reservoirs. The storage capacity of the Stephenville soil is low because sandstone occurs at a shallow depth. Because of sandiness, all these soils tend to dry out quickly. If surfaces are not protected they are subject to wind and water erosion. The Eufaula soil is subject to wind erosion but is not subject to serious water erosion. The mapping units are:

Dougherty fine sandy loam, 2 to 5 percent slopes.
Eufaula loamy fine sand, 1 to 4 percent slopes.
Minco soils, 2 to 5 percent slopes.
Stephenville fine sandy loam, 2 to 5 percent slopes.

These soils are suitable for a rotation of vetch and small grains, which provides good ground cover and ample organic residue. Sweetclover and small grains can be grown on these soils but they may require lime and phosphate before seeding. The Eufaula soils are not suited to terracing.

Provide for regular additions of organic matter and use contouring or terracing, as required, to control erosion. Provide ground cover for critical blowing periods. These soils are well suited to mixtures of bermudagrass and legumes. Smooth areas of Dougherty and Minco soils are well suited to a mixture of alfalfa and bromegrass. The Dougherty, Eufaula, and Minco soils make good sites for post lot plantings.

CAPABILITY UNIT IIIs-1

Deep, very slowly permeable claypan soils of level and gently sloping prairies

These dark silty soils formed on clayey Permian "Red Beds" and clayey shale of Pennsylvanian age. They are slowly to very slowly permeable. They are of moderately low fertility and are particularly deficient in phosphorus. They hold much water but have a fairly low moisture-supplying capacity. These claypan soils are not readily permeable to roots. Water tends to run off, and all slopes are subject to erosion. Eroded areas are droughty and of low fertility. The mapping units are:

Kirkland silt loam, 0 to 1 percent slopes.
Kirkland silt loam, 1 to 3 percent slopes.
Parsons complex, 1 to 3 percent slopes.
Renfrow silt loam, 1 to 3 percent slopes.

These soils are best suited to small grains, native grasses, and legumes other than alfalfa. Locally, alfalfa produces well on areas with deep surface horizons above the clays. These soils are not well suited to row crops although corn, grain sorghums, and cotton are grown on them to some extent.

Use shallow ditches to dispose of excess water on the more nearly level areas, and build terraces on slopes of more than 1½ percent if tilled crops are to be grown on them. Best forage yields can often be obtained from small grains or small grain-vetch mixtures grown as winter pasture and spring hay crops. They also leave good residues to protect the land between crop seasons. Bermudagrass, overseeded with vetch, is a moderately good mixture for tame pasture. On eroded areas weeping lovegrass or native grasses grow better than domestic grasses.

CAPABILITY UNIT IVe-1

Sloping, very slowly permeable and slowly permeable prairie soils that have clay subsoil

These dark-colored silty or loamy soils formed from red clay, and from sandy shales, clay shales, and sandstones, on nearly level to moderate slopes. Some have lost a part of their topsoil and have clay at a shallow depth. They are droughty and erode easily if tilled. They are low in organic matter and low in fertility. The mapping units are:

Dennis loam, eroded, 3 to 5 percent slopes.
Dennis complex, 5 to 8 percent slopes.
Kirkland silt loam, eroded, 1 to 3 percent slopes.
Parsons complex, eroded, 1 to 3 percent slopes.
Renfrow silt loam, 3 to 5 percent slopes.
Renfrow silt loam, eroded, 3 to 5 percent slopes.

These soils are best suited to small grains, winter legumes, and native grasses. A year of row crops can be grown following sod crops, if contouring and terracing are used to control erosion. Seed eroded areas to weeping lovegrass or to native grasses. Bermudagrass, overseeded with hop clover, lespedeza, or vetch, makes a fairly good mixture for tame pastures. However, better forage yields may be expected most years from small grains or small grain-vetch mixtures grown for winter pasture and spring hay crops. These also leave good residues to protect the land between crop seasons.

CAPABILITY UNIT IVe-2

Strongly sloping, permeable, responsive soils that gully readily

These pale-brown to dark-brown silty or sandy soils formed from materials laid down by both water and wind within 1 to 2 miles of the flood plains of larger streams. The soils are well drained to excessively drained and are moderately permeable to rapidly permeable. They have

low to moderate moisture-supplying capacity. They are of moderate to low fertility. The mapping units are:

Dougherty fine sandy loam, 5 to 8 percent slopes.
Eufaula loamy fine sand, 4 to 8 percent slopes.
Norge silt loam, 5 to 8 percent slopes.
Teller soils, 5 to 10 percent slopes.

These soils are well suited to native grasses, to bermudagrass and legume mixtures, to alfalfa and bromegrass, and to orchard or post lot trees. Weeping lovegrass grows well. The soils are not well suited to row crops, but an occasional row crop can be grown safely if it follows a sod crop and terraces, contouring, and other erosion control measures are used. Along the bottom lands, diversion terraces may be needed on these soils to protect the lowlands from sanding and silting. A rotation of a small grain and legume can be used if a moderately high level of fertility is established. Fruits and vegetables may be grown successfully. Plant orchards on the contour. These soils make good sites for post lot plantings.

CAPABILITY UNIT Vw-1

Dissected and hummocky bottom-land soils locally subject to frequent overflow

This capability unit consists of deep fertile areas on narrow flood plains, sandy alluvial soils along rivers, and other dissected areas in bottom-land soils. In places they are frequently flooded. With the exception of small patches useful for crops or gardens, these areas are not suitable for cultivation. The mapping units are:

Mixed alluvial land.
Sandy alluvial land.

Most of these areas are forested and are well suited to growing hardwood trees. They are good sites for post lot plantings. Cleared areas are well suited to bermudagrass and legumes. Johnsongrass meadows grow well on some areas.

CAPABILITY UNIT VIs-1

Slightly developed, shallow or stony prairie soils on strong slopes

These soils formed from calcareous clays and interbedded limestone, neutral clay shales and sandstones, and from interlayered red clay beds and sandstones. They are not suited to cultivation. The mapping units are:

Sogn, Talihina, and Collinsville soils, 3 to 20 percent slopes.
Vernon and Lucien soils, 5 to 15 percent slopes.

These soils are suited only to grasses. Control grazing to maintain a good growth of grasses. Use diversion ditches or terraces, as needed, to protect severely eroded areas for reseeding. Use native grasses in reestablishing the range.

These soils are not well suited to trees, but shelterbelts or windbreaks of redcedar, Chinese elm, or other trees can be grown for protection of farmsteads. Persimmon or sumac may invade grazing areas and reduce pasture yields. Post and blackjack oaks have, in places, invaded the Lucien and Collinsville soils.

CAPABILITY UNIT VIs-2

Slightly developed, shallow or stony wooded soils on moderate and strong slopes

The members of this capability unit are:

Darnell soils, 3 to 8 percent slopes
Dougherty and Eufaula soils, 8 to 15 percent slopes.

The Darnell soils formed from sandstones; the Dougherty and Eufaula soils, from deep sandy loams and loamy sands. Because these soils are shallow and have steep slopes, they are not suited to cultivation.

Although most of these soils are wooded, they grow native grasses well if the trees are removed or deadened. Bermudagrass and legumes do well on the Dougherty and Eufaula soils. Erosion is a hazard, and grazing must be carefully regulated on these soils so that they are kept well covered.

Some areas of Dougherty and Eufaula soils support good stands of post oak, black oak, blackjack oak, and redcedar. These areas are suitable for timber management and can produce sawlogs. These soils are also useful for post lot or windbreak plantings. Very few areas of Darnell have timber large enough to be useful except for posts or firewood, and they are not generally suited to post lot plantings.

CAPABILITY UNIT VIIe-1

Severely eroded sloping prairie soils, most of them gullied

The members of this capability unit are:

Dennis complex, severely eroded, 3 to 8 percent slopes.
Norge soils, severely eroded, 3 to 8 percent slopes.
Renfrow soils, severely eroded, 3 to 5 percent slopes.
Teller and Dougherty soils, severely gullied, 3 to 8 percent slopes.
Zaneis soils, severely eroded, 3 to 8 percent slopes.

These soils are not suited to crops, but under careful management, can be used for pasture. Protect against further sheet and gully erosion by diverting water on slopes above. Bermudagrass and legumes do well on these soils and will grow even better if fertilized. Weeping lovegrass and native grasses do well on all these soils and are probably better adapted on the Dennis complex and the Renfrow soils than bermudagrass. After abandonment, all these soils revegetate in time with native grasses.

CAPABILITY UNIT VIIs-1

Strongly sloping deep and shallow wooded soils too steep or too rocky for crops

Darnell-Talihina complex, 8 to 45 percent slopes, is the only mapping unit in this capability unit. The soils of this complex developed in natural sandstones and interbedded sandy and clayey shales. They are steep, rocky, and not suited to cultivation. Most areas occur above drainageways; some are blufflike and resemble mountains when viewed from the lower side.

These soils are moderately wooded, but most areas, if cleared, are suitable for grass. Carefully control grazing of native grasses to maintain suitable growth and mulch for soil protection. Many areas are so stony and shallow that removing or deadening the timber may be both hazardous and unprofitable. Only a few areas of deeper soils on lower slopes have any timber of value. The growth rate is so slow that timber management is not feasible. Post lot plantings are not advisable.

Estimated Yields

Estimated average acre yields of the principal crops on the soils of the county are given in table 5. Columns A show the crop yields to be expected under the management practices now being used on most of the farms in

TABLE 5.—*Estimated average acre yields of principal crops under two levels of management*

[Yields in columns A are to be expected under the management most farmers in the county are practicing; those in columns B are to be expected under improved management; where yield figure is not given, soil is not well suited to the crop or is little used for that crop]

Soil	Corn		Wheat		Oats		Cotton		Sorghum for grain		Sorghum for forage		Alfalfa		Native hay
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Lb.*	*Lb.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Bates fine sandy loam, 2 to 5 percent slopes	15	20	10	14	28	32	180	230	13	18	1.4	1.8			1.1
Brewer silty clay loam	35	60	18	26	35	60	300	400	30	45	2.9	4.3	3.3	4.0	
Brewer-Drummond complex	18	35	10	16	25	32	180	240	20	26	2.2	2.5	2.2	3.3	.8
Cleora fine sandy loam	20	30					250	330	18	28	1.8	2.7	3.0	4.0	
Dale silt loam	40	65	20	30	35	55	390	500	35	50	3.3	4.5	3.5	4.5	1.6
Darnell soils, 3 to 8 percent slopes							90	130	6	10	.7	1.1			.6
Darnell-Talihina complex, 8 to 45 percent slopes															
Dennis loam, 2 to 5 percent slopes	18	26	12	18	21	35	230	300	16	26	1.8	2.5	2.1	3.0	1.2
Dennis loam, eroded, 3 to 5 percent slopes	12	16	8	12	14	27	160	210	12	16	1.3	1.8			
Dennis complex, 5 to 8 percent slopes															1.0
Dennis complex, severely eroded, 3 to 8 percent slopes															
Dougherty fine sandy loam, 2 to 5 percent slopes	14	22	10	15	16	24	130	220	15	24	1.6	2.4	1.8	2.5	
Dougherty fine sandy loam, 5 to 8 percent slopes	10	20	9	13	14	22	110	180	12	22	1.3	2.5	1.6	2.2	
Dougherty and Eufaula soils, 8 to 15 percent slopes															
Eufaula loamy fine sand, 1 to 4 percent slopes	9	15					70	130	8	12	.9	1.3			
Eufaula loamy fine sand, 4 to 8 percent slopes	8	14					60	120	6	10	.7	1.1			
Kirkland silt loam, 0 to 1 percent slopes	18	24	14	20	22	33	230	310	17	25	1.8	2.5	2.0	3.0	1.4
Kirkland silt loam, 1 to 3 percent slopes	18	24	13	20	20	30	220	300	17	24	1.8	2.5	2.0	3.0	1.2
Kirkland silt loam, eroded, 1 to 3 percent slopes			7	10	12	20	160	220	10	15	1.1	1.7			
Lela soils	32	45	20	30	30	50	320	400	27	35	2.6	3.3	3.2	4.0	1.6
Miller clay	30	42	16	20	30	42	330	400	28	38	2.7	3.7			1.8
Minco soils, 2 to 5 percent slopes	14	22	10	15	16	24	130	200	15	22	1.7	2.5	1.8	2.5	
Mixed alluvial land															
Norge fine sandy loam, 2 to 5 percent slopes	16	22	12	16	20	32	200	260	13	18	1.3	1.7	2.1	3.0	1.2
Norge silt loam, 2 to 5 percent slopes	23	33	14	22	23	38	220	320	20	30	2.0	2.9	2.3	3.2	1.2
Norge silt loam, 5 to 8 percent slopes			12	18	20	30			16	22	1.7	2.2			1.1
Norge soils, severely eroded, 3 to 8 percent slopes															
Parsons complex, 1 to 3 percent slopes	16	22	10	16	20	32	210	290	18	24	1.7	2.4	1.8	2.3	1.0
Parsons complex, eroded, 1 to 3 percent slopes			6	9	12	20	130	180	10	14	1.0	1.4			
Port silt loam	35	60	17	27	35	55	340	430	30	40	2.9	4.3	3.1	4.0	1.6
Renfrow silt loam, 1 to 3 percent slopes	16	22	12	18	22	32	200	260	16	24	1.7	2.4	2.0	2.8	1.2
Renfrow silt loam, 3 to 5 percent slopes	15	20	10	18	20	30	180	230	15	22	1.6	2.3	1.8	2.4	1.1
Renfrow silt loam, eroded, 3 to 5 percent slopes			7	10	12	20	150	190	8	15	.8	1.6			
Renfrow soils, severely eroded, 3 to 5 percent slopes															
Sandy alluvial land															
Sogn, Talihina, and Collinsville soils, 3 to 20 percent slopes															.8
Stephenville fine sandy loam, 2 to 5 percent slopes			8	12	14	20	100	140	10	18	1.0	1.7			.8
Summit clay loam, 3 to 5 percent slopes	20	26	14	20	24	36	220	300	18	26	1.8	2.5	2.4	3.2	1.2
Teller soils, 2 to 5 percent slopes	20	32	12	18	20	32	240	320	20	32	2.0	3.1	2.5	3.4	1.4
Teller soils, 5 to 10 percent slopes	15	22	10	14	16	26	210	260	15	21	1.6	2.2	2.2	3.0	1.1
Teller and Dougherty soils, severely gullied, 3 to 8 percent slopes															
Vanoss silt loam, 0 to 2 percent slopes	25	35	15	21	28	42	300	400	25	35	2.5	3.3	2.6	3.5	1.5
Vernon and Lucien soils, 5 to 15 percent slopes															.8
Yahola silt loam	40	60	18	28	35	55	360	500	32	48	3.1	4.4	3.5	4.5	2.0
Yahola fine sandy loam	22	42	13	20			240	280	24	36	2.4	3.3	3.2	4.0	1.4
Zaneis soils, 2 to 5 percent slopes	17	24	12	18	20	35	200	240	16	23	1.7	2.3	2.0	2.8	1.2
Zaneis soils, severely eroded, 3 to 8 percent slopes															

the county. Columns B give the yields that can be expected under improved management.

The yield estimates are based on information obtained from farmers of the county, the county agricultural agent, and from observations made during the survey. A study of the records of the Agricultural Stabilization Committee gave added information. Many yield estimates were obtained from soils that had large acreages in crops; these were considered reliable. Yields on soils covering smaller areas were estimated by comparison with the soils for which reliable yield estimates were available.

The estimated yields are given as average yields that can be expected over a period of years. They do not apply to specific tracts of land for any particular year. Climate fluctuates from year to year; and management practices vary from farm to farm. Small areas within some soils are not like the surrounding areas, so they do not yield the same. In eroded areas the crop yields are normally reduced. A soil with an abnormally deep surface soil will produce yields higher than the average. On soils of the uplands the average yield of corn and grain sorghums varies greatly from year to year.

Ordinary management, which produces the average yields in columns A, includes contour tillage on sloping lands, use of suitable plant varieties, planting and tilling at the proper time, insect control and normal harvesting methods. No regular systems of fertilizing or of using legumes in the crop rotation are practiced.

The normal cropping pattern on the medium and fine-textured soils of the uplands is alfalfa and corn planted on the deepest, most permeable soils; cotton and grain sorghums on the shallower, more clayey soils; and small grains on both these groups. Normally corn follows a small grain, and cotton follows corn, which in turn is followed by a small grain. In many places a small grain is drilled after the cotton land has been double-disked to work in the trash.

On the bottom lands there is little effort to rotate crops, even though this would be beneficial. Here, corn normally follows corn, or cotton follows cotton. A small grain is often planted late, following the harvest of either cotton or corn. Corn follows alfalfa for at least 2 years.

On the sandy soils of the uplands, large areas of row crops are not common. Corn and sorghums are the most widely grown summer crops. Rye is the most common small grain. Normally 1 or 2 years of row crops or of small grains will be planted after the soil has been left idle several years, during which time its store of available nutrients increases.

The improved management needed to get yields in columns B includes the practices used in ordinary management plus additional practices to improve soils and increase crop yields. (See discussion of management by capability units.) These added practices include a rotation of field and legume crops, use of fertilizers with the legumes, and the use of starter fertilizer and side dressing fertilizer in production of row crops.

Management of Range and Native Meadows

Livestock raising is a major enterprise in Pawnee County. Grassland is the backbone of this industry. About 55 percent of the county is in native grass, and slightly more than 20 percent has a wooded overstory and varying amounts of grass in the ground cover.

A high yield from rangeland is important to all livestock growers. The kind, the amount, and the management of the vegetation on the range determine the number of cattle that can be grazed each year. Only by using grass properly can high sustained yields be obtained. Following is a list of some important grasses, trees, plants, and weeds in Pawnee County. The list is arranged to indicate, in a general way, the location and use of the various kinds of vegetation. For more specific information on range vegetation and its management, the reader can refer to the subsection, Range Sites and Conditions.

Native Grasslands

Dominant grasses:	
Andropogon scoparius	Little bluestem.
A. gerardi	Big bluestem.
Panicum virgatum	Switchgrass.
Sorghastrum nutans	Indiangrass.
Minor grasses:	
Bouteloua curtipendula	Sideoats grama.
B. gracilis	Blue grama.
Buchloe dactyloides	Buffalograss.
Tripsacum dactyloides	Eastern gamagrass.
Native legumes:	
Amorpha canescens	Leadplant.
Baptisia spp	Wildindigo.
Desmanthus illinoensis	Illinois bundleflower.
Lespedeza capitata	Roundhead lespedeza.
L. procumbens	Trailing lespedeza.
L. virginiana	Slender lespedeza.
Psoralea tenuiflora	Wild alfalfa.
Common forbs:	
Helianthus spp	Perennial sunflower.
Ratibida columnaris	Prairie coneflower.
Silphium laciniatum	Compassplant.
Woody plants:	
Prunus augustifolia	Chicksaw plum.
Rhus glabra	Smooth sumac.
Symphoricarpos orbiculatus	Buckbrush.

Heavily Grazed Native Grasslands

Grasses that increase with grazing:	
Andropogon purpurea	Purple three-awn.
A. saccharoides	Silver bluestem.
A. ternarius	Splitbeard bluestem.
A. virginicus	Broomsedge bluestem.
Aristida oliganthа	Prairie three-awn.
Sporobolus spp	Annual dropseed.
Grasses and plants that do not become dominant:	
Andropogon hallii	Sand bluestem.
Cenchrus pauciflorus	Mat sandbur.
Eragrostis spectabilis	Purple lovegrass.
Setaria lutescens	Yellow bristlegrass
Smilax hispida	Greenbrier.
Strophostyles spp	Trailing wildbean.
Triodia flava	Purpletop.
Urtica spp	Stinging nettle.
Vernonia baldwini	Ironweed.
Invading undesirable grasses and weeds:	
Ambrosia psilostachya	Ragweed.
Aristida spp	Perennial three-awn.
Bromus secalinus	Cheatgrass.
Diodia teres	Poorjo.
Erigeron canadensis	Horseweed.
Grindelia squarrosa	Rosinweed.
Gutierrezia dracunculoides	Annual broomweed.
Helianthus spp	Sunflowers.
Plantage purshil	Wooly plantain.
Rudbeckia hirta	Black-eyed-susan.

Bottom-land Forests

Dominant trees:	
Celtis occidentalis	Hackberry.
Hicoria spp	Pecan.
Plantanus occidentalis	Sycamore.
Populus deltoides, virginiana	Cottonwood.
Quercus spp	Oaks.
Ulmus americana	American elm.
Minor trees:	
Acer rubrum	Red maple.
Flaxinus pennsylvanica	Green ash.
Gleditsia triancanthos	Honeylocust.
Juglans nigra	Black walnut.
Morus rubra	Mulberry.
Salix spp	Willows.
Ulmus serotina	Red elm.
Shrubs and small trees in understory:	
Bumelia languinosa	Chittamwood.
Cephalanthus occidentalis	Buttonbush.
Cercis canadensis	Redbud.
Cornus asperifolia	Rough-leaved dogwood.
Psedera quinquefolia	Virginia creeper.
Rhus toxicodendron	Poison-ivy.
Sapindus drummondi	Chinaberry.
Smilax spp	Greenbrier.
Symphoricarpos spp	Buckbrush.
Vitis spp	Wildgrapes.
Ground cover:	
Carex spp	Sedges.
Galium aparine	Bedstraw.
Panicum anceps	Beaked panicum.
Panicum Virgatum	Switchgrass.
Paspalum floridanum	Florida paspalum.
Phytolacca americana	Pokeweed.
Polygonum pennsylvanicum	Smartweed.
Sorghum halepense	Johnsongrass.
Spartina pectinata	Prairie cordgrass.
Tripsacum dactyloids	Eastern gamagrass.
Uniola latifolia	Broadleaf spikegrass.

Upland Forests

Dominant trees:	
Hicoria spp	Hickory.
Quercus marilandica	Blackjack oak.
Q. stellata	Post oak.
Minor trees:	
Juniperus virginiana	Eastern redcedar.
Quercus velutina	Black oak.

Weeds in Cultivated Fields

Amaranthus spp	Pigweed.
Ambrosia spp	Ragweed.
Amrosia trifida	Giant ragweed.
Bromus secalinus	Cheatgrass.
Chenopodium album	Lambsquarter.
Croton texensis	Croton.
Digitaria spp	Crabgrass.
Erigeron canadensis	Muletail.
Grindelia squarrosa	Rosinweed.
Helianthus spp	Sunflowers.
Hordeum spp	Foxtail.
Solanum elaeagnifolium	Horse nettle.
Solanum rostratum	Buffalobur.
Verbascum thapsus	Mullein.

Planted Trees and Grasses

Post lots and windbreaks:	
Catalpa speciosa	Catalpa.
Morus rubra	Red mulberry.
Robinea pseudo-acacia	Black locust.
Toxylon pomifera	Osage-orange.
Ulmus parvifolia	Chinese elm.
Juniperus virginiana	Eastern redcedar.
Street shade trees:	
Acer rubrum	Red maple.
Catalpa speciosa	Catalpa.
Robinea pseudo-acacia	Black locust.
Ulmus americana	American elm.
Ulmus parvifolia	Chinese elm.
Lawn grass:	
Cynodon dactylon	Bermudagrass.

Principles of Grassland Management

Native range grasses are a crop. Like any other crop, they respond to management. To get the most from his rangeland, the rancher should select the kind of livestock to which his grazing land is best suited, limit the number of livestock and the season of grazing, and control the distribution of grazing animals.

Kind of livestock.—Cattle are best suited to the rangeland in Pawnee County. Sheep are not particularly well suited, because their habits of close grazing and trailing damage the native tall grasses and may encourage erosion of the steeper soils.

Number of livestock.—The number of livestock placed on the range should be decided according to the length of time that the range will be grazed and the amount of forage available. Enough forage should be left on the ground to—

1. Mulch the soil and increase the amount of water that soaks into and stays in the soil. More soil moisture means more grass.
2. Permit deep vigorous growth of grass roots. Enough growth should be left on each plant to provide the food to be stored in the plant for early and vigorous growth in spring. Generally, about half of the growth can be removed without damaging the vigor and productivity of a plant.
3. Protect the soil from wind and water. A good cover of grass will prevent erosion and hold much of the water where it falls.
4. Allow grass to crowd out weeds and other inferior plants. This will improve the condition of the range.
5. Provide a reserve of feed for periods of drought that otherwise might force sale of livestock at a time when prices are low.

Season of use.—Grasses that grow well during cool weather generally supply the earliest grazing in spring, as well as some grazing in fall. Warm-season grasses should be pastured during the summer months. The nutritional value of native grasses declines as the plants approach maturity, so the grasses should be grazed or cut for hay when they provide the most nourishment. Most of the grasses in Pawnee County grow faster during spring and early summer. Livestock gain weight most rapidly during this period.

The kinds and amounts of grass that a range site will produce and the best time for grazing the site depend on the condition of the range. Range in poor to fair condition normally should be rested until fall or winter, as this permits the better grasses to spread from underground stems and by seeding.

Ranges in good or excellent condition can benefit from occasional rest from grazing during the season when the principal forage plants make their best growth. A local representative of the Soil Conservation Service can advise on seasons of use and rest for individual range sites.

Distribution of grazing.—Much rangeland in Pawnee County is overgrazed in some places and undergrazed, or not grazed at all, in others. The distribution of grazing can be controlled by locating water and salt, by fencing, and by herding.

Poor distribution of water is one of the main causes of uneven grazing. Watering places should be developed over the entire range, if possible, so that livestock do not have to walk too far to get a drink. Generally, water is required at about 1-mile intervals in rough country, and at 2-mile intervals on more level range.

Salt should be placed in lightly grazed areas where forage is abundant and where livestock can reach it from several directions. It should not be placed in sandy or other erodible places. Livestock do not need water and salt at the same location.

Fences are necessary to provide separate pastures for different kinds of livestock and for different seasons of use. Where possible, fences should be located on the boundary between two range sites so that livestock will not overgraze the preferred range site and graze the other site too lightly. Herding is sometimes useful in keeping cattle on the desired range sites at the proper seasons.

Range Sites and Conditions

The carrying capacity of rangeland depends on the site in which it occurs and on the condition of the plants growing in that site. Range sites and range conditions are defined as follows:

RANGE SITE: A range site is an area that, because of its conditions of climate, soil, and topography, will support a certain kind of climax vegetation. The climax vegetation is the vegetation originally on the site that will maintain and reproduce itself as long as the environment is unchanged. If the natural balance between vegetation and environment is upset by overgrazing, burning, or like causes, the native plants may die and be replaced by others.

RANGE CONDITION: The condition of rangeland is determined by comparing the kind and amount of vegetation now growing with the kind and amount that grew before the land was heavily grazed or cultivated. The four range conditions are named and defined as follows:

Excellent: 76 to 100 percent of the vegetation now growing consists of plants that were in the original cover.
Good: 51 to 75 percent of the vegetation now growing consists of plants that were in the original cover.
Fair: 26 to 50 percent of the vegetation now growing consists of plants that were in the original cover.
Poor: 0 to 25 percent of the vegetation now growing consists of plants that were in the original cover.

Range condition is affected by past and present intensity of grazing or mowing, frequency of burning, burning when plants are most subject to damage, and by droughts or wet seasons.

If only 40 to 60 percent of the growth in the current year is grazed off, enough root growth and seed will be left to allow the better range plants to dominate in the sod. Sites in poor or fair condition can be improved to good or excellent condition through restriction of grazing.

Description of range sites

The six range sites—Prairie, Hardland prairie, Prairie breaks, Deep Cross Timbers, Shallow Cross Timbers, and Bottom land—are described in the following pages.

Prairie site.—The deep, dark-colored soils characteristic of this site favor good growth of roots and storage of moisture. Under good management, the productive tall prairie grasses are dominant. These grasses are abundant: big bluestem, little bluestem, Indiangrass, switchgrass, and sideoats grama.

Common, though not abundant, in well-managed areas are native perennial legumes.

If heavy grazing is continued, this site is invaded by less desirable plants. Among these are silver bluestem, western ragweed, ironweed, annual broomweed, annual three-awn, and numerous other annual plants.

The following soils are in this site:

Bates fine sandy loam, 2 to 5 percent slopes.
Dennis loam, 2 to 5 percent slopes.
Dennis loam, eroded, 3 to 5 percent slopes.
Dennis complex, 5 to 8 percent slopes.
Minco soils, 2 to 5 percent slopes.
Norge silt loam, 2 to 5 percent slopes.
Norge silt loam, 5 to 8 percent slopes.
Norge soils, severely eroded, 3 to 8 percent slopes.
Norge fine sandy loam, 2 to 5 percent slopes.
Summit clay loam, 3 to 5 percent slopes.
Teller soils, 2 to 5 percent slopes.
Teller soils, 5 to 10 percent slopes.
Zaneis soils, 2 to 5 percent slopes.
Zaneis soils, severely eroded, 3 to 8 percent slopes.

Hardland prairie site.—The characteristically deep, dark-colored soils of this site somewhat limit growth of roots and have a lower moisture supplying capacity than soils of the Prairie site. Their subsoil is very slowly permeable.

Under good management, the high-yielding grasses on this site are little bluestem, big bluestem, Indiangrass, switchgrass, and sideoats grama, along with small amounts of buffalograss and blue grama. Common though not abundant in well-managed areas are native perennial legumes and palatable forbs.

If heavy grazing is continued, less palatable and less productive plants invade. Among these are silver bluestem, western ragweed, ironweed, annual broomweed, and annual three-awn. In many areas that are continuously and heavily grazed, buffalograss and blue grama become dominant. They form a low growth so matted that grazing animals cannot destroy all the plants. Nevertheless, the amount of forage produced is very low.

The following soils are in the Hardland prairie site:

Dennis complex, severely eroded, 3 to 8 percent slopes.
Kirkland silt loam, 0 to 1 percent slopes.
Kirkland silt loam, 1 to 3 percent slopes.
Kirkland silt loam, eroded, 1 to 3 percent slopes.
Parsons complex, 1 to 3 percent slopes.
Parsons complex, eroded, 1 to 3 percent slopes.
Renfrow silt loam, 1 to 3 percent slopes.
Renfrow silt loam, 3 to 5 percent slopes.
Renfrow silt loam, eroded, 3 to 5 percent slopes.
Renfrow soils, severely eroded, 3 to 5 percent slopes.

Prairie breaks site.—Because of local differences in the soils, the growth of grass on this moderately productive site varies widely. On many small areas growth of plant roots is restricted by shallow depth to sandstone, limestone, or shale. Most areas, however, have depth enough for good root growth, even though they are on steep slopes. This site is generally less productive than the Prairie site, and many parts of it are less accessible to livestock.

The taller grasses are present in the deeper soil areas and along cracks in the underlying hard rocks. Dominant among these are big bluestem, little bluestem, switchgrass, and Indiangrass. More abundant on the shallower parts are less productive grasses, including sideoats grama, hairy grama, blue grama, and tall dropseed.

Under heavy grazing, the shorter grasses such as hairy grama, blue grama, and perennial three-awn increase. Annual dropseed, annual three-awn, and annual broomweed also invade. Woody plants, particularly sumac

and persimmon, increase on this site if management is not good.

The soils of this site are the following:

Sogn, Talihina, and Collinsville soils, 3 to 20 percent slopes.
Vernon and Lucien soils, 5 to 15 percent slopes.

Deep Cross Timbers site.—The deep, sandy, productive soils of this site take moisture readily. In its original condition, the vegetation was grasses overtopped by thin stands of oak and hickory. The principal grasses were big bluestem, little bluestem, switchgrass, and Indiangrass.

The Dougherty and Eufaula soils in many places support stands of black oaks and post oaks that are of good form and density and grow at a fair rate. It may be better to manage some of these areas for forest products instead of grass.

Many species of native legumes are present, among them are Virginia tephrosia, trailing lespedeza, slender lespedeza, and roundhead lespedeza.

Much of the site has deteriorated because of frequent burning and heavy grazing. It now supports a dense stand of oaks. Old fields returning to permanent vegetation generally support a low-grade mixture of woody plants and grass. Effective control of brush is normally the first step to sound management.

The soils of this site are the following:

Dougherty fine sandy loam, 2 to 5 percent slopes.
Dougherty fine sandy loam, 5 to 8 percent slopes.
Dougherty and Eufaula soils 8 to 15 percent slopes.
Eufaula loamy fine sand, 1 to 4 percent slopes.
Eufaula loamy fine sand, 4 to 8 percent slopes.
Stephenville fine sandy loam, 2 to 5 percent slopes.
Teller and Dougherty soils, severely gullied, 3 to 8 percent slopes.

Shallow Cross Timbers site.—The soils of this site are shallow, mostly stony, and limited in moisture-holding capacity. Sandstone beds underlying the soils restrict penetration of moisture and growth of roots. About 60 percent of the acreage is on steep and stony hills called timbered breaks. The rest consists of shallow and very shallow soils on the moderate slopes of ridges.

In excellent condition, this site has a cover of grass and scattered clumps of post oak, blackjack oak, hickory, elm, and other trees. Trees are thinner and grasses are more abundant on the more clayey soils that occur along the outcrops of clay shale.

Grazing and frequent burning have resulted in a decrease in amount of grass and an increase in the scrubby oaks. Brush control is normally the first step in grazing management. Careful grazing is necessary because soils of this site erode severely if the ground cover is destroyed.

The soils of this site are the following:

Darnell soils, 3 to 8 percent slopes.
Darnell-Talihina complex, 8 to 45 percent slopes.

Bottom-land site.—The deep, productive soils of this site receive extra moisture from overflows, and a few areas have a high water table. The soils vary from sandy loams to clay, but all are nearly level and absorb water readily.

The native vegetation was bottom-land forest and grass. The forest stands ranged from thick to thin and were made up of cottonwood, elm, oak, hackberry, pecan, and other trees. Most of the forest has been removed or thinned. The pecan trees ordinarily were left. The areas of Brewer, Drummond, Dale, and Vanoss soils probably were mostly under a grass cover. If the site is in excellent condition, the principal grasses are eastern gamagrass, Florida paspalum, prairie cordgrass, switchgrass, big bluestem, and beaked panicum. Many of the silted overflow areas are in johnsongrass and bermudagrass. Bermudagrass is used extensively for revegetation of old fields and cleared areas. The following soils are in the Bottom-land site:

Brewer silty clay loam.
Brewer-Drummond complex.
Cleora fine sandy loam.
Dale silt loam.
Lela soils.
Miller clay.
Mixed alluvial land.
Port silt loam.
Sandy alluvial land.
Vanoss silt loam, 0 to 2 percent slopes.
Yahola silt loam.
Yahola fine sandy loam.

Suggestions on stocking rates

Typical stocking rates for the range sites in each of the condition classes are given in table 6. These are suggestions of typical rates likely to maintain the ranges in excellent and good condition and to improve those in poor condition. The amount of forage produced each year, however, depends greatly on the weather. The operator must continually study the condition of each of his ranges and adjust his grazing load and season of use to the amount of forage.

Ranges in fair or poor condition may need to have grazing deferred for one or more seasons in order to permit fairly rapid improvement.

TABLE 6.—*Typical stocking rates on the different range sites and condition classes*

[These are suggestions only; rates should be adjusted according to observed condition of the range]

Range site	Range condition			
	Excellent	Good	Fair	Poor
	Acres per cow per year	Acres per cow per year	Acres per cow per year	Acres per cow per year
Bottom land	4–5	6–10	11–20	21+
Prairie	8–10	11–15	16–25	26+
Hardland prairie	10–12	13–19	20–28	28+
Prairie breaks	12–15	16–23	24–32	33+
Deep Cross Timbers	9–11	12–17	20–30	31+
Shallow Cross Timbers	13–16	17–25	26–35	36+

Management of Native Hay

About 5 percent of the native grassland is used for hay. Most of the areas cut for hay are gently sloping and free of stones. Proper management of native hay meadows involves the same principles of management as those for range. The main problems in management of meadows are the date and frequency of mowing, fire, and the effects of winter grazing. Generally, one cutting a year, late in June or early in July, will permit better grass recovery

and give a healthier meadow than later cutting. Two cuttings a year will rapidly deplete root reserves and plant vigor and will not allow annual seeding.

After early mowing, the stock should not be allowed to graze until after frost. Grazing during the seeding period harms the grass. Winter grazing should be moderate, because heavy use and trampling tend to remove mulch and leave the stand open to invasion of annual three-awn and other weeds.

When mowing native grass, the cutter bar should be set to cut at least 3 inches high. This leaves enough leaf surface for soil protection; also it permits the grasses to recover, even though mowing is followed by drought.

Soil Associations

The colored map at the back of this report shows the soil associations, or general areas of soils, in Pawnee County. This map is helpful in studying the soils of the county for broad program planning. It is not sufficiently detailed to be useful in studying the soils of a farm. Each association contains several different kinds of soils arranged in characteristic pattern. The pattern is related to the nature of the soil materials and, in most places, to the shape of the land surface.

It can be seen from the map that the dark-colored and reddish soils of the Reddish Prairie group comprise 60 percent of the area. The dark-colored soils occupy the central and eastern areas; the reddish soils are mostly in the west. The difference in color of the soils is caused mainly by color differences in parent material.

Dennis-Bates-Talihina-Sogn

The dark-colored Dennis, Parsons, Bates, Collinsville, and Talihina prairie soils of the eastern part of the county have developed on slightly acid sandstone, siltstone, and clay shale. The Summit and Sogn soils have developed on limy shale and limestone. This association covers about 36 percent of the county. About 59 percent of this acreage is made up of deep soils and 41 percent of shallow soils.

The block diagram (fig. 11) illustrates the relations of the prairie soils of central and eastern Pawnee County. The Dennis is the dominant deep soil of the association. It formed in undulating areas on the siltstone and interbedded clay shale and sandstone. In some places the Dennis has formed on colluvial slopes below areas of the steeply sloping Sogn, Talihina, and Collinsville soils. The latter are associated thin, stony grassland soils formed on clay shale and sandstone.

The Parsons soil is related to the Dennis, but it is a claypan soil that formed in the clay shale on gentle slopes or upland flats. The Bates is a sandy soil that has developed in sandstone and sandy shale; the Collinsville is a stony, shallow soil associated with the Bates soil. The Summit is a moderately deep soil over limy clays that occurs in narrow bodies on colluvial slopes below areas of Sogn soil. The Sogn, a shallow soil over limy bedrock, occurs on and near the steeply sloping limestone escarpments.

About 35 percent of the deep soils of this association is cultivated to wheat, oats, cotton, grain sorghums, alfalfa, and similar crops. There are many prairie meadows and large areas of tall-grass pasture. The shallow soils are in native range, some of which is invaded by weeds.

Renfrow-Zaneis-Vernon-Lucien

Between Quay and Pawnee the escarpment formed by the Red Eagle limestone marks the change in the color and nature of rocks in the county. Through this area the gray and brown shale and sandstone and light-gray limestone are gradually replaced by red sandstone and limy clay. North of Pawnee this change is closer to the outcrop of the Neva limestone, which forms a prominent escarpment along Oklahoma Highway 18 (*2*). In this area of transitional rocks the reddish Renfrow, Zaneis, Vernon, and Lucien soils of the prairies become important. They are dominant in the western part of the county. This association covers about 24 percent of the county. Deep soils make up about 72 percent of this acreage and shallow soils about 28 percent.

The Kirkland, Renfrow, and Vernon soils formed on the fairly extensive soft red clay beds; Zaneis and Lucien soils occur on the less extensive sandstone and thinly banded sandstone and clay beds (fig. 12).

The Renfrow is the dominant soil that has formed on red clay on slopes; the Kirkland, a dark soil, has formed on similar materials on very gentle slopes and broad divides. The Vernon are thin soils that have developed mostly in calcareous red clays on steep slopes. The Zaneis, more friable soils than Renfrow, have developed

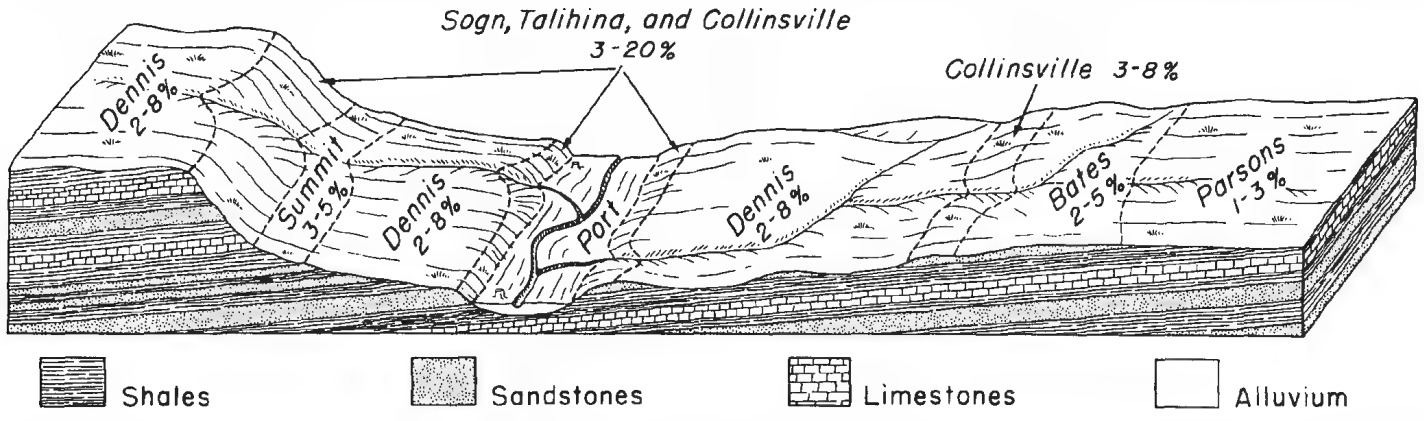

Figure 11.—**Prairie soils of central and eastern Pawnee County formed in sandstone, shale, and limestone, and in accompanying alluvium.**

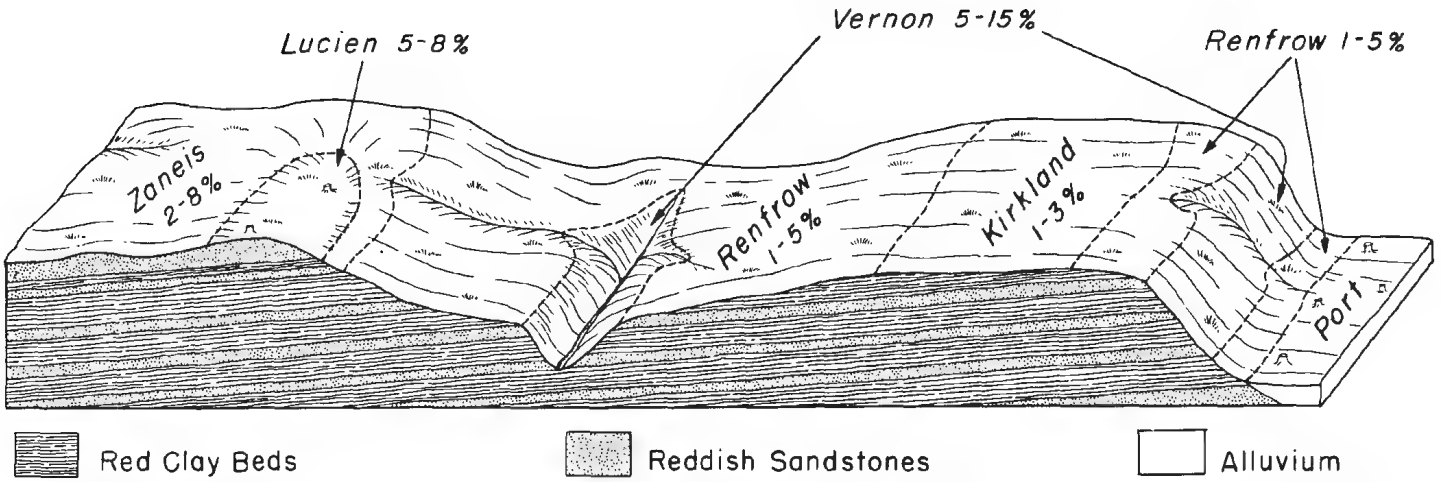

Figure 12.—**Prairie soils of western Pawnee County formed in clay and sandy strata of the Permian "redbeds" area, and in accompanying alluvium.**

on slightly acid sandstone thinly banded with clay. They are associated with the Lucien, a shallow, grassland soil over sandstone on moderate slopes. The Vernon and Lucien soils are very closely associated on the interbedded clays and sandstones.

About 40 percent of the acreage of the deep soils are cultivated, mainly to wheat, grain sorghums, cotton, and oats. Many areas support tall-grass meadows, and there are large areas of mixed grass prairies. All the shallow soils are in native range.

Darnell-Talihina-Stephenville

Soils of this association are located in the Cross Timbers, or oak woodlands, which interrupts the prairie sections of eastern Oklahoma. The areas are underlain by sandstone or loose sandy deposits and the soils are much lighter in color than those of the grasslands. This association covers about 15 percent of the county. Deep soils make up only about 3 percent of this acreage and shallow soils the rest.

The Darnell and Stephenville soils have developed under forest in brown and reddish sandstone. The Talihina soils have formed in brown and gray shales and sandstones, and the Pottsville in acid clay shale under a thin oak forest (fig. 13). The Darnell are very thin sandy soils that have many rock outcrops; the Stephenville are medium-depth soils with a developed sandy clay subsoil over sandstone; the Talihina are thin, stony soils of prairie openings that have a loamy surface soil over clay shale. The Pottsville are thin, stony, light-brown soils over clay shale.

A large part of this association is wooded. Some areas have thin woods over tall grasses. Others are covered with dense oak thickets and have little grass in the ground cover. Open areas of Talihina soils are mostly grassy or only slightly brushy. Nearly all of the association is used for grazing, but the value of the forage varies widely. About 30 percent of the acreage of the Stephenville soils is cultivated.

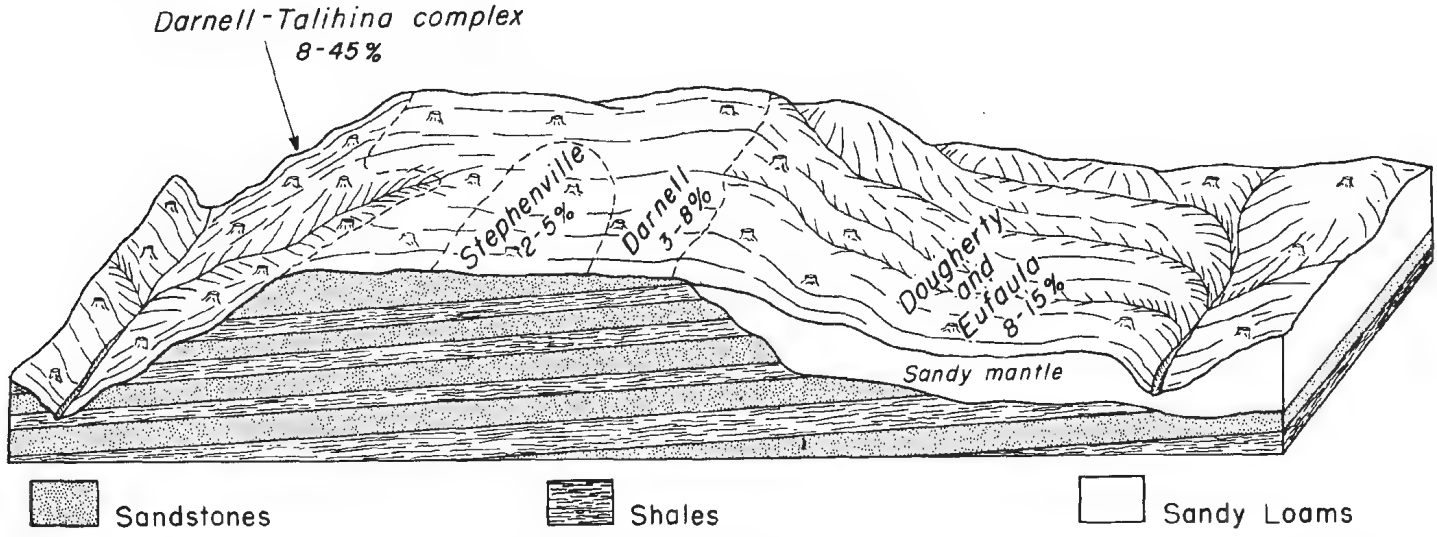

Figure 13.—**Woodland soils of the eastern part of the county formed in sandstone and shale, and in soft, sandy mantle material.**

Port-Yahola-Dale-Brewer

The deep soils of this association develop on alluvium on flood plains and low benches. The Dale and Minco soils occur on friable materials near the bottom lands of the Arkansas and Cimarron Rivers. The Minco soils develop on slightly wavy surfaces on what appears to be windblown material. The Dale forms on nearly level areas—former river bottom lands. The Brewer soil and Brewer-Drummond complex develop on clayey materials and occur on strips along the inland stream flood plains slightly above the present bottom lands. In many places the alluvial sediments have been modified by dark, local sediments washed down onto them from adjoining steep slopes. None of these low terrace soils exhibits strong development—they are young soils. This association covers about 13 percent of the county. Deep soils make up all of this acreage, but only about 70 percent of the association is arable.

The present bottom lands are narrow strips not exceeding a mile in width. The deposits are neutral to alkaline in reaction and range from clays to clay loams, and from silt loams to sandy loams. The clays occupy very level or depressed areas. Here the floodwaters move very slowly or are intermittently ponded so that the fine materials settle out. In the valleys of the Arkansas and Cimarron Rivers, these clayey areas are inextensive and are mapped as Miller soils. The more extensive sandy loams and silt loams underlie areas of Yahola silt loam and Yahola sandy loam. In Black Bear and other creek bottoms, clay areas form fairly large bodies near the junctions of side streams and are classed as Lela soils.

In all of the inland stream bottoms, silt loams and clay loams are the dominant group of alluvium. On these the Port soils develop. They form on high bottoms of deeply entrenched streams that seldom overflow.

Low, narrow bottoms occur along the streams of the eastern part of the county that drain Reddish Prairie and Cross Timber areas. On these develop the dark, sandy loam and loam soils of the Cleora series. These soils are overflowed more often than the Port soil.

About 76 percent of this association is cultivated to cotton, corn, alfalfa, small grains, and similar feed crops. Some narrow or inaccessible areas are wooded, and a few areas are improved for pasture. Native range is important.

Sandy alluvial land and Mixed alluvial land lie near stream channels. These areas have irregular, or broken surface relief and overflow each year. They are subject to continual sedimentation and to shifting and reworking by floodwaters. These areas are not cropped.

Norge-Teller-Vanoss

The soils of this association have one feature in common: They developed in materials of alluvial and wind-transported origin that are relatively high in weatherable minerals. These materials are partly of loess, which was deposited on upland areas from 20 to 180 feet above the present bottom lands. Most of these materials range from very fine sandy loams to clay loams, and the soils on them—Norge, Teller, and Vanoss—are medium textured. These soils have developed under tall grasses and are typical soils of the prairies (fig. 14). This association covers about 10 percent of the county. Deep soils make up all of this acreage.

The Norge soils have formed in materials that have lain in place a long time. They have a well-developed clayey subsoil. Norge fine sandy loam occurs on the dissected alluvial plain along Black Bear Creek. The Teller and Vanoss are younger soils than the Norge. They have developed in friable material that has not lain in place as long as that under the Norge. The Teller soils are brown and have a reddish subsoil. The Vanoss soil has developed on more nearly level areas and is darker throughout.

About 60 percent of this association is cultivated, and the rest is in tall-grass pasture and meadow. Generally this association is the most productive of the upland part of the county.

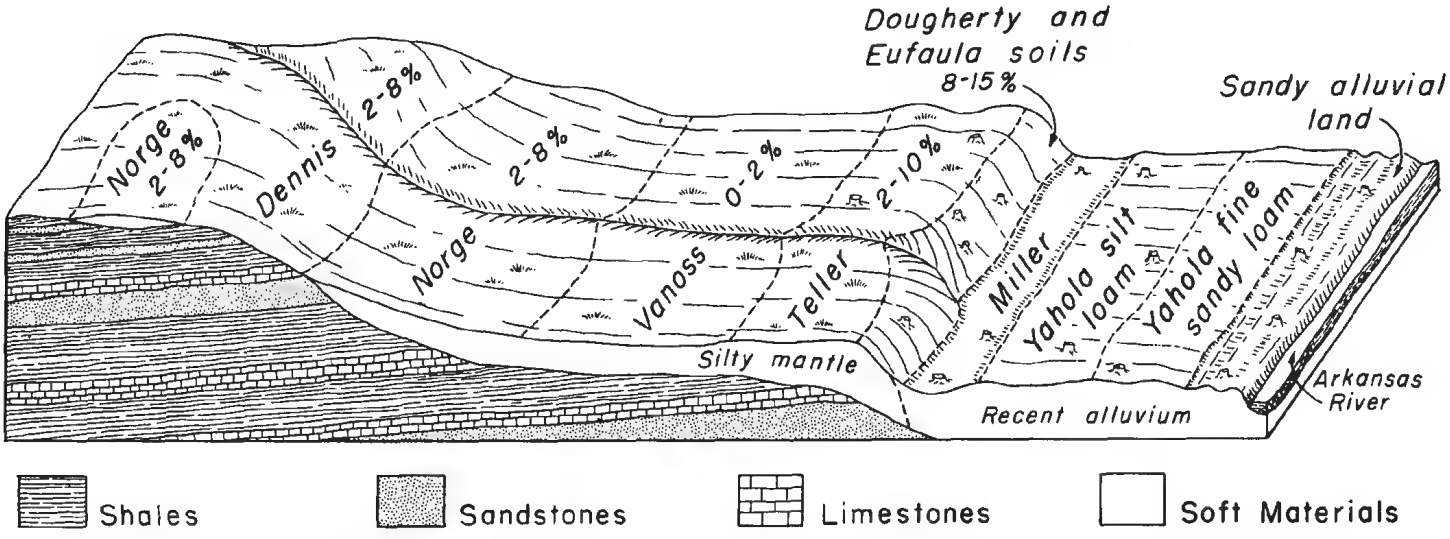

Figure 14.—**Prairie and forest soils formed in recent alluvium, and in adjoining areas of silty and sandy mantle material.**

Dougherty-Eufaula

Soils in this association are sandy; they have developed sandy clay loam layers that lie from 12 to 30 inches deep under the Dougherty soil. Under the Eufaula soil the layers are thin and erratic, and normally they lie deeper than 30 inches. This association is made up entirely of deep soils, but it covers only 2 percent of the county.

The soils of this association are forested; they have developed from sandy high-terrace material overblown with sandy loess from the bottom lands of the Arkansas and Cimarron Rivers in times past. The remaining forest growth consists of scrubby post, blackjack, red and black oaks, and some redcedar and hickory.

About 20 percent of the association is in crops. About 45 percent was formerly cultivated, but it is now reverting to grass. The rest is in forest. The cultivated soils are moderately productive. They are well suited to common field crops, orchard fruits, vegetables, and other summer crops.

Engineering Properties of Soils [3]

This section records the properties of soils important to engineering in terms familiar to the engineer. Table 7 provides for five soils in Pawnee County the classification used by the American Association of State Highway Officials (AASHO), the liquid limit, the plasticity index, compaction test data, and mechanical analysis. The engineering characteristics of the other soils in the county are then inferred by comparison with these five soils.

In interpreting table 7, it is to be assumed that the characteristics of a given soil remain fairly uniform, wherever the soil appears in the county. Thus, the engineer can get from the soil survey much information that he would otherwise have to obtain himself. The data, however, are not a substitute for the detailed tests needed at a site selected for construction.

Explanation of Terms

The following simplified definitions of terms and methods are provided for those without an engineering background who are interested in engineering properties of soils.

AASHO classification.—The American Association of State Highway Officials has developed a classification based on the field performance of soil materials. In this classification, soil materials are placed in seven groups, designated A–1, A–2, A–3, A–4, A–5, A–6, and A–7. Some of the groups are divided into subgroups. The soil materials in each group are valued by means of a group index, a number that takes into account the behavior of soil materials in embankments, subgrades, and subbases. The essentials of the classification are shown in table 8, which also gives, for each class, the nature of the material and the stability of the material.

Liquid limit.—The moisture content at which a soil is sufficiently fluid to flow a specific amount when jarred lightly 25 times in a standard apparatus, hence, the moisture content at which a soil passes from the plastic to the liquid state.

Plastic limit.—The moisture content at which a spindle of soil can be rolled, without breaking, to a diameter of only one-eighth inch; or the lowest moisture content at which the soil remains plastic.

Plasticity index.—The numerical difference between the liquid limit and plastic limit. The plasticity index indicates the range of moisture content in which a soil is in a plastic condition. Nonplastic, indicated by NP, applies to soils that are granular or without cohesion, for which liquid or plastic limit cannot be determined.

Compaction test.—If a soil material is compacted at successively higher moisture contents, assuming that the compactive effort remains constant, the density of the compacted material will increase until the optimum moisture content is reached. After that, the density decreases with increases in moisture content. The highest dry density obtained in the compaction test is termed "maximum dry density." Moisture-density data are important in earthwork, for as a rule optimum stability is obtained if the soil is compacted to about the maximum dry density, when it is at approximately the optimum moisture content.

Mechanical analysis.—The particles of various sizes in soil material affect the behavior of the material when used for engineering purposes. Table 7 gives the percentage of gravel, sand, silt, and clay in samples from five soils. The analyses were made by sieve and hydrometer methods. The names for the various sizes of sand, silt, and clay used by engineers are not equivalent to the names used in agriculture. For example, *fine sand,* as defined by the United States Department of Agriculture, consists of particles 0.25 to 0.10 millimeters in diameter; whereas *fine sand,* in engineering terminology, consists of particles 0.42 to 0.074 millimeters in diameter.

Soil Groups for Engineering

The engineering properties of most of the soils in Pawnee County can be inferred by comparison with the five soils listed in table 7.

Dougherty fine sandy loams, the first soils in table 7, are fairly stable when dry but unstable when wet. By adding coarse sand, their strength under all weather conditions probably can be increased. If properly handled, these soils furnish good material for a subgrade. Extensive proportions of these soils have a preponderance of very sandy material that may be suitable for use in subbases. Other soils in Pawnee County that should behave about like Dougherty fine sandy loams are the following:

Darnell soils, 3 to 8 percent slopes.
Dougherty and Eufaula soils, 8 to 15 percent slopes.
Minco soils, 2 to 5 percent slopes.
Stephenville fine sandy loam, 2 to 5 percent slopes.
Teller and Dougherty soils, severely gullied, 3 to 8 percent slopes.
Yahola fine sandy loam.
Yahola silt loam.

Port silt loam, the third soil in table 7, is good material for fills and is usually suitable for subgrades if properly compacted. Material from the less plastic, sandy portions of this soil may be made suitable for use in a subbase by properly combining with coarse sand and other coarse

[3] This section was written by MORELAND HERRIN, Civil Engineering Department, Oklahoma A and M College.

TABLE 7.—*Engineering tests data* [1]

Soil name and horizons	Depth	Bureau of Public Roads sample No.	AASHO classification [2]	Liquid limit [3]	Plasticity index [4]
	Inches				
Dougherty fine sandy loam, 2 to 5 percent slopes:					
A_{1p}	0–7	89067	A–2–4 (0)	[7] NP	NP
B_2	18–36	89068	A–4 (1)	23	8
C	58–94+	89069	A 4 (7)	21	3
Dougherty fine sandy loam, 5 to 8 percent slopes:					
A_1	0–8	89070	A–4 (8)	NP	NP
B	24–34	89071	A–2–4 (0)	23	7
C	42–80+	89072	A–2–4 (0)	NP	NP
A_1	0–7	89073	A–4 (0)	NP	NP
B_2	20–36	89074	A–4 (4)	19	4
C	36–110+	89075	A–2–4 (0)	NP	NP
Port silt loam:					
A_1, C_1, C_2, (composite)	0–36	89066	A–4 (7)	25	7
A_1, C, (composite)	0–36	89076	A–6 (11)	37	18
A_1, C_1, C_2, (composite)	0–36	89083	A–6 (8)	29	11
Dennis loam, 2 to 5 percent slopes:					
A_1	0–8	89063	A–4 (8)	30	10
B_2	18–36	89064	A–7–6 (18)	50	29
C	48–72+	89065	A–7–6 (19)	56	36
A_1	0–8	89077	A–6 (9)	34	12
B_2	18–48	89078	A–7–6 (17)	49	27
C	44–80+	89079	A–6 (10)	31	15
A_1	0–10	89080	A–4 (6)	26	7
B_2	18–44	89081	A–7–6 (18)	51	33
C	44–78+	89082	A–6 (8)	27	11
Kirkland silt loam, 1 to 3 percent slopes:					
A_1	0–12	89084	A–4 (8)	20	3
B_2	14–26	89085	A–7–6 (19)	54	33
C	44–85+	89086	A–6 (7)	31	16
A_1	0–14	89087	A–5 (8)	29	9
B_2	14–30	89088	A–7–6 (19)	54	31
C	44–92+	89089	A–7–6 (18)	50	30
A_1	0–12	89090	A–6 (10)	38	14
B_2	15–34	89091	A 7–6 (15)	45	24
C	46–96+	89092	A–7–6 (18)	51	31

[1] Tests performed by the Bureau of Public Roads in accordance with standard procedures of the American Association of State Highway Officials.

[2] See text for explanation of symbols.

[3] Moisture content, expressed in percent, at which soil will pass from plastic to liquid.

[4] Plasticity index is the difference between the liquid limit and plastic limit, expressed as a number. The number indicates the range in moisture content in which a soil stays plastic.

TABLE 8.—*Essentials of AASHO*

[For complete classification of soil and soil-aggregate mixtures see: AASHO Designation: M 145-49,

General classification	Coarse-grained materials (35 percent or less passing No. 200 sieve)				
Group classification	A–1		A–3 [1 2]	A–2	
	A–1–a	A–1–b [2]		A–2–4	A–2–5
Group index	0	0	0	0	0
Material	Stone fragments, gravel, and sand.	Stone fragments, gravel, and sand.	Fine beach sand or blow sand.	Silty gravel and sand.	Silty gravel and sand.
Stability	Highly stable at all times.	Highly stable at all times.	Highly stable when confined.	Stable when dry, but easily worn away by traffic.	Stable when dry, but easily worn away by traffic.

[1] Placing of A–3 before A–2 is necessary in the left-to-right elimination process and does not indicate superiority of A–3 over A–2.

on 5 soils of Pawnee County, Okla.

Compaction test [5]		Mechanical analysis [6]						
Maximum dry density	Optimum moisture	Gravel (more than 2.0 mm.)	Coarse sand (2.0–0.42 mm.)	Fine sand (0.42–0.074 mm.)	Silt (0.074–0.005 mm.)	Clay (less than 0.002 mm.)	Clay (less than 0.005 mm.)	Colloids (less than 0.001 mm.)
lb./cu. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
112	12	0	1	66	27	3	6	2
120	12	0	1	60	18	18	21	16
117	12	0	0	29	55	14	16	13
111	12	0	1	25	67	5	7	4
118	14	0	2	68	10	19	20	19
115	11	0	5	80	5	8	10	8
108	13	0	1	37	53	6	9	6
122	12	0	1	43	40	14	16	13
118	11	0	2	74	14	7	10	5
114	15	0	0	28	49	20	23	18
110	17	0	0	4	58	32	38	29
115	14	0	0	5	67	23	28	20
110	14	0	1	13	62	20	24	18
106	20	0	1	10	47	37	42	36
105	20	0	1	12	40	43	47	42
106	17	0	1	17	55	22	27	20
106	19	0	1	12	44	38	43	35
115	15	0	1	15	50	28	34	26
110	15	0	0	36	48	14	16	12
106	19	0	0	20	36	39	44	37
117	14	16	1	12	41	21	30	18
115	13	0	1	25	60	11	14	10
102	21	0	0	12	42	40	46	37
115	15	0	0	44	25	28	31	26
110	15	0	0	5	71	20	24	19
103	20	0	0	1	51	42	48	39
106	20	0	1	6	52	37	41	35
102	19	0	0	9	65	22	26	20
103	19	0	0	7	56	33	37	31
108	18	0	1	8	49	38	42	36

[5] See text for explanation of compaction test.

[6] Mechanical analyses given here are for engineering purposes and are not suitable for defining the texture classes for agriculture. *See:* Standard Methods of Mechanical Analysis of Soils, T 88–54, AASHO (*1*).

[7] NP—nonplastic.

classification of soils for engineering

In Highway Materials, published by the American Association of State Highway Officials (*1*)]

Coarse-grained materials (35 percent or less passing No. 200 sieve)		Silt-clay materials (More than 35 percent passing No. 200 sieve)				
A–2		A–4	A–5	A–6	A–7	
A–2–6	A–2–7				A–7–5	A–7–6
4 maximum. Clayey gravel and sand. Good stability.	4 maximum. Clayey gravel and sand. Good stability.	8 maximum. Moderately plastic silts. Fair stability when dry; poor when wet.	12 maximum. Highly elastic silts. Doubtful stability; difficult to compact.	16 maximum. Medium plastic clays. Good stability if properly compacted.	20 maximum. Highly plastic clays. Fair stability if well drained.	20 maximum. Highly plastic clays. Fair stability if well drained.

[2] A–1–b and A–3 do not appear in analyses in table 7.

materials. Other soils in Pawnee County that should behave about like Port silt loam are the following:

Bates fine sandy loam, 2 to 5 percent slopes.
Cleora fine sandy loam.
Dale silt loam.
Mixed alluvial land.
Norge fine sandy loam, 2 to 5 percent slopes.
Teller soils, 2 to 5 percent slopes.
Teller soils, 5 to 10 percent slopes.
Vanoss silt loam, 0 to 2 percent slopes.

Dennis loam, 2 to 5 percent slopes, is an extensive soil and the fourth in table 7. It provides fair to poor materials for fills and may be suitable for use in subgrades, but it must be properly compacted and provision must be made for adequate surface drainage of the earth structure. Other soils of Pawnee County that should behave about like Dennis loam are the following:

Dennis loam, eroded, 3 to 5 percent slopes.
Norge silt loam, 2 to 5 percent slopes.
Norge silt loam, 5 to 8 percent slopes.
Norge soils, severely eroded, 3 to 8 percent slopes.
Zaneis soils, 2 to 5 percent slopes.
Zaneis soils, severely eroded, 3 to 8 percent slopes.

Kirkland silt loam, 1 to 3 percent slopes, the last soil in table 7, represents a group of soils not particularly desirable for road construction. The Kirkland soils are composed predominantly of material that is sticky when wet and it is difficult to dry the wet material to the moisture content that is required for proper compaction. The clays in these soils swell and shrink greatly with changes in moisture content. Other soils of Pawnee County that should behave about like the Kirkland are the following:

Brewer silty clay loam.
Brewer-Drummond complex.
Dennis complex, 5 to 8 percent slopes.
Kirkland silt loam, 0 to 1 percent slopes.
Kirkland silt loam, eroded, 1 to 3 percent slopes.
Lela soils.
Miller clay.
Parsons complex, 1 to 3 percent slopes.
Parsons complex, eroded, 1 to 3 percent slopes.
Renfrow silt loam, 1 to 3 percent slopes.
Renfrow silt loam, 3 to 5 percent slopes.
Renfrow silt loam, eroded, 3 to 5 percent slopes.
Renfrow soils, severely eroded, 3 to 5 percent slopes.
Summit clay loam, 3 to 5 percent slopes.

Soils not listed in table 7, but excellent for road construction are Eufaula loamy fine sand, 1 to 4 percent slopes; Eufaula loamy fine sand, 4 to 8 percent slopes; and Sandy alluvial land. These soils are easily compacted within a wide range of moisture content and can be readily stabilized with asphalt to provide a good all-weather road.

The soil complexes that developed from bands of sharply contrasting parent materials will have widely different engineering properties. Areas of these complexes should be checked rather closely. In general, their engineering properties will be a composite, or mixture, of the properties of the soils in the complex. The complexes of this kind in Pawnee County are the following:

Darnell-Talihina complex, 8 to 45 percent slopes.
Sogn, Talihina, and Collinsville soils, 3 to 20 percent slopes.
Vernon and Lucien soils, 5 to 15 percent slopes.

The complex of Darnell and Talihina soils probably will behave about like the soils of the Dennis group. The Sogn, Talihina, and Collinsville complex, as well as the complex of Vernon and Lucien soils, should react about like the soils of the Kirkland group. Nevertheless, in areas where a complex contains more than the normal proportion of the sandy Collinsville or the Lucien soils, the behavior of the material should be about like that of soils in the Dennis group.

Variation in Soils

The placement of some of the soils in the major groups is approximate. Alluvial soils, particularly are variable because of differences in stratification. Thus, some of Yahola fine sandy loam might be grouped with Eufaula loamy fine sands and Sandy alluvial land, whereas some of Yahola silt loam might behave like the soils in the Port silt loam group.

Some parts of the Minco areas have properties closely similar to the Eufaula loamy fine sands and Sandy alluvial land. Parts of the extensive Dennis loam areas are physically more similar to the soils of the Kirkland silt loam group than to soils of the Dennis loam group.

The foregoing will serve to point out the variations the field engineer should watch for in his study of soils for construction purposes. Details concerning the variation in any given soil will be found in the section, Descriptions of the Soils.

Origin, Classification, and Morphology of Soils

Factors of Soil Formation

Soil is the product of the forces of weathering and soil development acting on the parent material deposited or accumulated by geologic agencies (*11*). The characteristics of the soil at any given point depend on (1) the physical and mineralogical composition of the parent material; (2) the climate under which that material has accumulated and has existed since accumulation; (3) the plant and animal life in and on the soil; (4) the relief or lay of the land; and (5) the length of time the forces of development have acted on the soil material. The climate, and its influence on soil and plants, depends not only on temperature, rainfall, and humidity, but also on the physical characteristics of the soil or soil material and on the relief, which, in turn, strongly influences drainage, aeration, runoff, erosion, and exposure to sun and wind.

Parent material

The parent material of the soils of Pawnee County consists of disintegrated and partly weathered rocks and of loose alluvial or windblown materials. These materials have weathered from hard limestone (*2*), moderately hard sandstone, and layers of slightly compacted shales, soft sandstones, and clays. The alluvial and windblown parent materials consist of loose sands, friable sandy loams, and clay loams. The unconsolidated materials that occur in the mantled areas and in the bottom lands have been weathered considerably. With little further change, the unconsolidated materials form parent material, and the soils have developed directly on these materials.

The parent materials vary greatly in depth from place to place. They are deepest in loess, alluvium, soft rock, and other unconsolidated deposits. They are shallow in

areas underlain by resistant rock, particularly on steep slopes where the soil erodes almost as fast as it forms.

The siltstones, shales, and clays have resisted penetration of water, and soils have formed slowly on them. Soils have formed faster on the sandy materials, which have been readily penetrated by water.

The clays, shales, siltstones, and loamy unconsolidated materials have developed into soils that have a clayey subsoil. These soils can hold the basic elements that are released by further weathering. The sandstone and sandy unconsolidated materials have developed into soils with a subsoil that contains little clay. The basic elements are readily leached from these soils.

Vegetation

Grasses generally grow well in areas of low and medium rainfall. Forests cover regions where the rainfall is more plentiful. Bluestem grasses (*Andropogon* spp.) dominate in about 70 percent of the county. They cover soils that have surface soils of sandy loam or finer texture. These grasses grow best on medium- and fine-textured soils that are high in plant nutrients. Such soils have developed on the more clayey rocks and on loess and alluvium. The roots of these grasses absorb the water that penetrates the upper layers of the soils.

Post oak, blackjack oak, and similar trees are dominant on the sandy soils, which are low in plant nutrients. These trees grow in the sandy uplands where moisture that penetrated the soils during the growing season can be reached by the tap roots of the trees. Some hardwoods that require more plant nutrients than post oak or blackjack oak have dominated on the alluvial bottom lands, which are rich in minerals and high in moisture. Where these hardwoods are removed, a thick growth of grass soon covers the soil.

The fibrous roots of the prairie grasses, which penetrate to depths of 18 to 24 inches or more, have supplied large amounts of organic matter to the soils. These grasses use nearly all the rain that falls during the growing season, and the leaching of plant nutrients is thus reduced. Burrowing animals, earthworms, protozoa, fungi, and bacteria help convert raw plant remains into organic matter. The organic matter darkens the soil. It helps produce a granular structure and increases water-holding capacity. As the organic matter breaks down, nitrogen that is needed for plant growth is released.

Under deep-rooted grasses, calcium carbonate and other compounds gradually go into solution during the formation of soil, and they are not leached away rapidly. Part of these compounds is returned to the surface soil in the grass litter. The surface soil formed under these conditions is slightly acid. Soils that develop under grasses therefore retain their native fertility longer than soils that develop under trees. Reddish Prairie soils are formed under grasses in this county.

Trees differ from grasses in their effect on the formation of soils. The feeding roots of post oak and blackjack oak are fibrous and do not penetrate the soil deeply. The tap roots are woody and penetrate deeply. They may take in plant nutrients that are dissolved directly from the parent material or rock. Although large amounts of leaves fall from the trees, much of this litter is oxidized in the warm climate under an open-canopied forest and does not return to the soil in organic form. Because trees live many years, they give only small amounts of organic matter directly to the soil. The roots, however, do aid in keeping the soil open and pervious to water, and in forming new soil material by wedging and cracking rocks.

Under trees on the sandy soils, water percolates rapidly. This water carries the weak acid that is formed during the decomposition of leaves. The basic elements of the soil are leached away by the acid. At the same time, sandy clay layers that are colored by traces of iron oxides are formed in the lower part of the soil. These layers retain moisture and plant nutrients in proportion to their thickness and the amount of clay that they contain. Light-colored Red-Yellow Podzolic soils are formed under forests. These soils are less fertile than the dark, granular Reddish Prairie soils that have formed under grasses.

Soils that developed under the hardwood forests of the bottom lands differ from those formed under the oak of the uplands. In the bottom lands alluvium accumulated and prevented great loss from leaching. The organic remains were incorporated to considerable depths by being mixed with the new alluvium. Alluvial soils that have developed in this way have their surface soils enriched with organic matter. Most of these soils have a surface layer darkened by organic matter to depths of 8 to 18 inches.

Climate, relief, and time

The temperate, subhumid climate of Pawnee County varies little from place to place. The formation of the soil of the county is affected more by the amount of rainfall than by any other climatic factor. The fact that different kinds of soils have developed under a similar climate indicates that parent material and vegetation have affected the development of the soils of the county more than climate.

Relief, which affects the amount of rainfall that is absorbed by the soil, ranges from nearly level on alluvial flats to strongly sloping and steep on the uplands.

The length of time that the soils of the county have been developing is reflected in the degree of horizon development of the soils. On the uplands, are the Reddish Prairie soils, which have been developing for long periods and have distinct horizons. Alluvial soils, on the bottom lands, have been developing for a short time and show little horizon development.

Geology

Pawnee County is underlain by rocks of Pennsylvanian and Permian ages (*6*). These rocks formed from sediments dropped in the seas that covered large sections of the United States millions of years ago. At that time the earth's crust was extremely unstable, and, as it rose and fell, the seas moved back and forth across the land. The climate was warm and moist, and plants and primitive forms of life were in the waters. The vegetation that later became peat, and finally coal, grew abundantly in the great marshes. Oil, now reached under cappings of sandstone, was formed in much the same way as coal.

The oscillation of the ancient seas deposited many thin strata that later became sedimentary rocks. The limestones formed in shallow, warm, still waters; the siltstones, in deeper waters; and the sandstones, near the edges of great seas where stronger currents prevailed.

Toward the end of the Pennsylvanian age and to a greater extent in the Permian age, the climate became more arid, high mountains rose, and the types of plant and animal life changed markedly. Exposed rocks oxidized markedly, and the material weathered from these rocks—red because of the oxidation—was washed into the receding seas. These red sediments give rise to the widely distributed redbeds of Texas and Oklahoma. The redbeds are of Permian age. Also deposited in the Permian age were the great salt beds. One of them is the bed at Great Salt Plains, near Cherokee, Oklahoma. The salt beds are evidence of the change in climate. Not having the rainfall of the Pennsylvanian time, trapped seawater evaporated and left salt in these Permian rocks.

All these sedimentary rocks were deposited level, but through central Oklahoma, they have a westward dip occasioned by the Flint Hills monocline. This has raised the eastern parts of these strata relative to their former level. This dip amounts to an average 40 feet per mile.

From eastern Pawnee County to the west the following formations are exposed. Wann, Barnsdall, and Tallant are mostly of gray and brown shales with thin and thick beds of sandstone. The Vamoosa formation includes the thick-bedded Elgin sandstone which caps the hills south of Cleveland and some hard gray formations, near Terlton. In this area the rocks are folded and faulted somewhat to interrupt the normal westward dip and produce local irregularities in the landscape. From Jennings west to Pawnee the undifferentiated Vanoss and Ada formations and Admire group are of a succession of gray, brown, and red shales, thin gray limestones, and moderately thick brown sandstones. The Council Grove group near Pawnee includes three hard gray limestones, the Red Eagle, Neva, and Cottonwood, which produce prominent east-facing escarpments that can be traced far to the north and south. Limestone members are thickest where they enter the county on the north and thinner at the south where limestone is partly replaced by sandstone. In this area rocks become redder, and the clays are not generally shaly. Only the reddish sandstones are distinctly hardened. They are part of the Chase group of the Wellington formation, which are of Permian age. Only the Fort Riley limestone produces any prominent escarpments in western Pawnee County.

Bands of reddish, unconsolidated windblown and alluvial materials are common on the uplands along the Arkansas and Cimarron Rivers and Black Bear and Camp Creeks. Usually the sandy deposits are on the north sides of the streams, and the silty and clayey deposits, on the south sides. These materials were derived from the wide alluvial bottom lands along the earlier rivers. They were deposited as alluvium or were blown onto the uplands through long periods that probably began in the Pleistocene period of glacial time. Even today, during very dry seasons, considerable fine sand and silt is blown onto the uplands from dry river channels and sandy bottom lands.

Catenas

A catena is a chain, or sequence, of soil series that developed from about the same kind of material but under different conditions of drainage (*10*).

In table 9 the soil series of the county are grouped into catenas and some of the characteristics that caused the differences in the series are given. Some catenas are represented in the county by only one soil series.

Classification of Soils

Soils are classified so that the results of agricultural research and the experience gained on specific tracts of soils can be applied to wider areas of similar soils. The higher categories of soil classification are the soil orders and great soil groups. The soil orders —zonal, intrazonal, and azonal—are the broadest categories in soil classification. Soils are grouped in these three orders mainly on the basis of degree of profile development. The soil orders are subdivided into great soil groups, which are broad groups of soils that have similar fundamental characteristics. A great soil group consists of many soil series. The soil series and other lower categories of soil classification are defined in the section, Soil Survey Methods and Definitions. In table 10 the soils series of the county are classified by soil orders and great soil groups.

Zonal soils

The zonal soils occur over large areas and have well-developed soil characteristics. Zonal soils reflect the dominant influence of the active soil-forming factors, that is, climate and vegetation. They generally develop in undulating, well-drained uplands on parent material that has been in place long enough for the soil-forming factors to form well-developed soils. The zonal soils that occur in Pawnee County are members of the Reddish Prairie and Red-Yellow Podzolic great soil groups.

Intrazonal soils

Intrazonal soils have characteristics that are not so well developed as those of zonal soils. Their development has been affected more by relief and parent material than by climate and vegetation. The intrazonal soils of Pawnee County occur in association with zonal soils in areas where the land is level or in areas where the parent materials are clayey or contain large amounts of soluble salts. The intrazonal soils in Pawnee County are of the Planosol and Solonetz great soil groups.

Azonal soils

Azonal soils have poorly developed characteristics because of their youth, or because some factor of parent material or relief has impeded development. The thin, stony soils on steep slopes and the very young soils of alluvial bottom lands are azonal soils. The azonal soils of Pawnee County are of the Alluvial, Lithosol, and Regosol great soil groups.

Morphology of Soils by Great Soil Groups

Except for Alluvial soils, the great soil groups of the county are discussed in the following pages by comparing all the soil series in the great soil group to the profile of one series that is representative of the group. Because Alluvial soils vary so much from place to place, no soil profile is representative of this great soil group. Detailed descriptions of the Alluvial soils are given in the section, Descriptions of the Soils.

TABLE 9.—*Soil series arranged by catenas,*[1] *and some of the characteristics of each series*

Position, vegetation, parent material, and soil series	Slopes	Surface drainage	Surface soil		Subsoil		Thickness to consolidated substratum
			Color	Structure and texture	Color	Structure and texture	
Soils of the uplands that developed under bluestem grasses from parent material of—							
Reddish calcareous clays:	*Percent*						*Inches*
Kirkland	0 to 3	Slow to very slow.	Dark grayish brown.	Granular silt loam.	Dark grayish brown mottled with dark brown.	Blocky clay	36–50
Renfrow	2 to 6	Moderate to slow.	Brown to reddish brown.	Granular silt loam.	Dark reddish brown.	Blocky clay	30–40
Vernon	5 to 15	Rapid	Brown to reddish brown.	Granular silt loam.	Dark reddish brown.	Blocky clay	4–15
Reddish brown neutral sandstones and shales:							
Zaneis	2 to 8	Moderate	Brown to reddish brown.	Granular loam	Reddish brown to red.	Granular to weak blocky clay loam to light clay.	24–44
Lucien	3 to 15	Moderately rapid.	Dark reddish brown.	Fine sandy loam.	Reddish brown	Structureless sandy clay loam and sandstones.	3–20
Grayish and olive brown shales and limestones:							
Summit	3 to 6	Moderate	Nearly black to dark brown.	Strong granular clay loam.	Grayish brown slightly mottled with olive brown.	Granular clay	26–36
Sogn	3 to 15	Rapid	Very dark grayish brown.	Strong granular clay loam.	Grayish brown and olive brown.	Interbedded clays and limestones.	2–15
Grayish brown (locally reddish brown) acid to alkaline clay shales:							
Parsons	0 to 3	Very slow	Grayish brown	Weak granular silt loam.	Very dark brown slightly mottled with yellowish brown.	Blocky clay	36–50
Talihina	5 to 20	Rapid	Dark grayish brown.	Granular clay loam.	Brown and grayish brown mottled with reddish brown.	Subangular blocky silty clay.	6–16
Gray and brown siltstones and sandstones:							
Dennis	2 to 8	Moderate	Dark grayish brown.	Granular loam	Mottled grayish brown, yellowish brown, and reddish brown.	Subangular blocky silty clay.	30–50
Bates	2 to 8	Moderate	Dark grayish brown.	Granular fine sandy loam.	Brown mottled with yellowish brown.	Granular sandy clay loam.	24–44
Collinsville	3 to 15	Moderately rapid.	Dark brown	Granular loam	Gray and brown	Interbedded sandstones and sandy shales.	2–15

See footnotes at end of table.

TABLE 9.—*Soil series arranged by catenas,*[1] *and some of the characteristics of each series*—Continued

Position, vegetation, parent material, and soil series	Slopes	Surface drainage	Surface soil		Subsoil		Thickness to consolidated substratum
			Color	Structure and texture	Color	Structure and texture	
Soils of the uplands that developed under bluestem grasses from parent material of—Continued							
Soft reddish clayey and clay loam Pleistocene earths:	*Percent*						*Inches*
Norge	2 to 8	Moderate	Dark brown	Granular silt loam and fine sandy loam.	Reddish brown	Granular silty and sandy clays.	60+
Vanoss	0 to 2	Slow to moderate.	Dark grayish brown.	Granular silt loam.	Brown to yellowish brown.	Granular clay loam.	60+
Teller	2 to 8	Moderate	Dark brown	Granular very fine sandy loam.	Reddish brown	Granular clay loam.	60+
Recent silty earths:							
Minco	0 to 4	Moderately rapid.	Brown	Weak granular very fine sandy loam.	Pink	Structureless very fine sandy loam.	60+
Soils of the uplands that developed under oak woodlands from parent material of—							
Gray and brown acid clay shale:							
Pottsville [2]	3 to 20	Rapid	Grayish brown or brown.	Weak granular loam or silt loam.	Gray and brown.	Interbedded clay shales and sandstones.	6–20
Brown and reddish brown sandstones:							
Stephenville	2 to 5	Moderate	Light brown	Weak granular fine sandy loam.	Yellowish red	Subangular blocky sandy clay.	20–30
Darnell	3 to 20	Moderately rapid.	Light brown	Weak granular light fine sandy loam.	Brown and reddish brown.	Sandstones	2–22
Soft reddish sandy loams:							
Dougherty	6 to 20	Moderately rapid.	Light brown	Weak granular	Yellowish red	Nearly massive light sandy clay.	60+
Brownish and reddish loamy sands:							
Eufaula	6 to 20	Moderate	Pale brown	Structureless loamy fine sand.	Yellowish red	Thin layers of sandy clay loam.	60+
Soils of the low terraces that developed under bluestem grasses and open forests on parent material of—							
Reddish alkaline clayey alluvium:							
Brewer	0 to 1	Slow	Very dark brown.	Granular silty clay loam.	Very dark brown.	Granular clay	60+
Drummond	0 to 1	Very slow	Pale brown	Platy silt loam	Very dark brown.	Blocky clay	60+
Brown silty alluvium:							
Dale	0 to 2	Slow to moderate.	Dark grayish brown.	Granular silt loam.	Dark brown	Very weak granular very fine sandy loam.	60+

See footnotes at end of table.

TABLE 9.—*Soil series arranged by catenas,*[1] *and some of the characteristics of each series*—Continued

Position, vegetation, parent material, and soil series	Slopes	Surface drainage	Surface soil		Subsoil		Thickness to consolidated substratum
			Color	Structure and texture	Color	Structure and texture	
	Percent						*Inches*
Soils of the flood plains that developed under hardwoods or parent material of—							
Reddish and brownish alkaline clayey alluvium:							
Miller	0 to ½	Very slow	Dark reddish brown.	Granular silty clay.	Reddish brown	Granular to massive clay.	60+
Lela	0 to ½	Very slow	Dark reddish brown.	Granular silty clay loam.	Reddish brown	Granular to massive clay.	60+
Reddish and brownish neutral loamy alluvium:							
Port	0 to 2	Slow to moderate.	Dark reddish brown to very dark brown.	Granular silt loam.	Reddish brown and brown.	Granular clay loam or silt loam	60+
Reddish and brownish alkaline sandy alluvium:							
Yahola	0 to 2	Moderate	Dark brown to reddish brown.	Weak granular silt loam to fine sandy loams.	Reddish brown	Weak granular silt loams and fine sandy loams.	60+
Grayish acid sandy and loamy alluvium:							
Cleora	0 to 2	Slow to moderate.	Dark grayish brown to brown.	Weak granular fine sandy loam.	Yellowish brown.	Weak granular fine sandy loam or loams.	60+

[1] A catena is a "chain" of soils developed from the same kind of material, but under different drainage. The soils of the catena are listed in sequence of improving drainage.

[2] Pottsville soil is not mapped separately in the county but is included with the Darnell-Talihina complex.

Reddish Prairie soils

The Reddish Prairie soils in the county are of the following series:

Bates.	Renfrow.
Brewer.	Summit.
Dennis.	Teller.
Kirkland.	Vanoss.
Norge.	Zaneis.

The Reddish Prairie soils have developed in the southern part of the tall-grass prairie region, under slightly lower rainfall and higher temperature than the Prairie soils of the northern part of the region. The tall-grass prairie region is in south-central Kansas, central Oklahoma, and central and southern Texas. The Reddish Prairie soils contain less organic matter in the surface layer than the Prairie soils and are slightly lighter colored. In many places they are redder because of the greater oxidation in the warmer climate.

Soils in the Reddish Prairie group have a brown to grayish-brown, slightly acid, granular surface soil that ranges from sandy loam to clay loam in texture. The subsoil is brown to reddish brown, clayey, and moderately to slowly permeable. It ranges from blocky to granular in structure. In this county, Reddish Prairie soils have developed in materials that range from sandstone and siltstone to weakly consolidated clay and unconsolidated clay loam. These materials range in color from olive brown and grayish brown to reddish brown and red. Table 11 gives the chemical and physical properties for samples of some Reddish Prairie soils that were collected in this county.

DENNIS soils are representative of the Reddish Prairie great soil group. The following description of Dennis loam was made from a profile 2½ miles south and 6 miles east of Pawnee:

A 0 to 12 inches, dark grayish-brown (10YR 4/1.5; 3.5/1.5, moist) loam; moderate medium granular structure; friable; moderately permeable; pH 6.0; upper 6 inches is slightly lighter colored than lower part; lower part contains a few worm casts; 1-inch transition to B_1 layer.

B_1 12 to 18 inches, dark grayish-brown (10YR 3.5/1; 3/2, moist) clay loam; strong medium granular structure; friable; hard when dry; moderately permeable; pH 6.0; contains numerous worm casts and tiny pinholes; fibrous roots penetrate the granules and spaces between; 1-inch transition to the B_2 layer.

B_2 18 to 26 inches, dark grayish-brown (2.5Y 4/2; 3/2, moist) silty clay or clay; about 10 percent of surface of aggregates finely mottled with reddish brown (5YR 4/4) and yellowish

TABLE 10.—*Soil series classified by orders, great soil groups, and series and some factors that influenced soil formation*

Great soil group and series	Parent material	Slope	Drainage	Vegetation
ZONAL SOILS				
Reddish Prairie:				
Bates	Gray and brown sandstones and sandy shales.	Moderate	Moderate	Tall grasses.
Brewer	Red, yellowish-red, and strong-brown clayey alluvium.	Level	Slow	Tall grasses.
Dennis	Gray and brown siltstone, sandy shales and sandstones.	Moderate	Moderate	Tall grasses.
Kirkland	Brown to reddish-brown soft, calcareous clayey redbeds.	Level to very gentle	Slow to very slow	Tall and medium-height grasses.
Norge	Red, yellowish-red, and strong-brown soft silty clays and gritty sandy clays.	Moderate	Moderate	Tall grasses.
Renfrow	Reddish-brown and red soft, calcareous redbeds.	Moderate	Moderate to slow	Tall and medium-height grasses.
Summit	Grayish-brown and olive-brown calcareous shales and limestones.	Moderate	Moderate	Tall grasses.
Teller	Red and yellowish-red soft clay loams and fine sandy loams.	Moderate	Moderate	Tall grasses.
Vanoss	Reddish-brown, brown, and strong-brown soft clay loams and fine sandy loams.	Level to very gentle	Slow to moderate	Tall grasses.
Zaneis	Reddish-brown, soft, moderately sandy redbeds.	Moderate	Moderate	Tall grasses.
Red-Yellow Podzolic:				
Dougherty	Yellowish-red and brown soft sandy loams	Gentle to strong	Moderately rapid	Oak trees.
Eufaula	Yellowish-red and brown soft loamy sands	Moderate to strong	Moderately rapid	Oak trees.
Stephenville	Brown to reddish-brown sandstones	Gentle	Moderate	Oak trees.
INTRAZONAL SOILS				
Planosols:				
Parsons	Grayish-brown to reddish-brown acid to alkaline clayey shales.	Level to very gentle	Very slow	Tall and medium-height grasses.
Solodized-Solonetz:				
Drummond	Reddish-brown to dark-brown alkaline to calcareous clay loams to clays.	Level	Very slow	Short grasses.
AZONAL SOILS				
Alluvial soils:				
Cleora	Grayish to yellowish-brown acid sandy and loamy alluvium.	Level to slightly wavy	Moderate	Trees.
Dale	Yellowish-red to brown loamy alluvium and windblown material.	Level	Moderate	Trees.
Lela	Reddish-brown and brown alkaline clays and clay loams.	Level to depressed	Very slow	Trees.
Miller	Reddish-brown and brown alkaline clays and stratified sands.	Level to depressed	Very slow	Trees.
Port	Reddish-brown to dark-brown neutral clay loams and silt loams.	Level	Slow to moderate	Trees.
Yahola	Reddish-brown to brown alkaline silty and sandy alluvium.	Level to slightly wavy.	Moderate	Trees.
Lithosols:				
Collinsville	Neutral to acid sandstones and sandy shales	Moderate to strong	Moderately rapid	Tall grasses.
Darnell	Brown and reddish-brown weakly acid sandstones.	Moderate to strong	Moderately rapid	Oak trees.
Lucien	Reddish-brown, weakly acid, soft, moderately sandy redbeds.	Moderate to strong	Moderately rapid	Tall grasses.
Pottsville [1]	Gray, brown, and reddish-brown acid clay shales and sandstones.	Strong to steep	Rapid	Oak trees.
Sogn	Grayish-brown and olive-brown calcareous shales and limestones.	Strong to steep	Rapid	Tall grasses.
Talihina	Gray, brown, and reddish-brown, neutral to acid shales and sandstones.	Strong to steep	Rapid	Tall grasses.
Vernon [2]	Soft, calcareous clayey redbeds and red shales.	Strong to steep	Rapid	Tall grasses.
Regosols:				
Minco	Brown to pink neutral, soft sandy loams	Undulating	Moderately rapid	Tall grasses.

[1] Pottsville soil not mapped separately in the county but is included in the Darnell-Talihina complex.

[2] Portions of Vernon developed on unconsolidated clays are Regosols. Because so much of it formed in material containing interbedded hard rocks it is classified here as a Lithosol.

red (5YR 5/6); compound moderate subangular blocky and coarse granular structure; firm; hard when dry; slowly permeable; pH 6.2; shiny organic coating on surfaces of aggregates; contains many small, black, shotlike pellets; 2-inch transition to the B_3 layer.

B_3 26 to 38 inches, grayish-brown (10YR 5/2; 4/2, moist) silty clay; about 15 percent coarsely mottled with reddish brown (5YR 4/4) and yellowish red (5YR 5/5); weak blocky structure; very firm; very hard when dry; slowly permeable; pH 6.5; faint shine on sides of the aggregates; contains numerous small, black pellets and a few small fragments of partially weathered sandstone; transition to C horizon is gradual.

C 38 to 46 inches +, yellowish-brown (10YR 5/4) sandy clay; mottled with yellowish brown (10YR 5/4), brown (7.5YR 5/4), and yellowish red (5YR 5/6); soft, partly weathered sandstone and shale fragments in the mass; in lower part gradual transition to practically unweathered olive-gray and reddish sandy shale and interbedded soft brown sandstone; pH 7.0; stained with very dark brown, particularly on the sides of the sandstone fragments.

This profile described is on a slope of about 2 percent and has good surface drainage. Formerly the area had a cover of bluestems, but it is now cultivated. It is relatively uneroded.

Zaneis and Norge soils are similar to the Dennis soils, and the layers in their profiles are about the same. They both have a brown surface soil and a reddish-brown subsoil. The Norge soils have yellowish-red parent material. Because their parent material contains less clay, the subsoil of the Norge and Zaneis soils is more granular and more permeable than that of the Dennis.

Teller, Vanoss, and Bates soils have an arrangement of soil layers similar to the Dennis, but they developed in more sandy and permeable materials than the Dennis. Their subsoil ranges from granular silty to sandy clay loam. The Vanoss soils have developed in soft, reddish materials on nearly level areas. They have a dark surface layer and upper subsoil like the Dennis. The Teller soils have formed in similar material on more sloping areas. They have a browner surface layer and are more reddish brown in the lower layers. The Bates soils are dark like the Dennis soils, and they have developed on a similar landscape in clay loams weathered from fine-grained sandstones and sandy shales.

Renfrow and Kirkland soils have a more clayey and more alkaline subsoil than the Dennis because they have developed in soft calcareous clay. Also, the upper subsoil, or B_1 layer, is only slightly developed or missing, and there is a maximum transition of 2 inches between the surface soil, or A horizon, and the subsoil, or B_2. Because of the clayey nature of its subsoil, the Kirkland, in many areas, is called a claypan soil. The Renfrow has a brown surface soil and a reddish-brown clay subsoil. The Kirkland, like the Dennis, has a dark grayish-brown surface layer and upper subsoil. Its parent rocks are brown or reddish brown. The Kirkland soils have developed on gentle slopes where deep water and grass-root penetration have resulted in a deeply developed, dark soil that has accumulations of calcium carbonate concretions at greater depths than in the Renfrow soils.

Summit and Brewer soils have similar profiles. The Summit formed on foot slopes, and the Brewer, just above the bottom lands. These soils have a very dark brown granular clay loam surface layer and a dark-brown granular clay subsoil over a neutral to calcareous substratum. The Brewer soils have formed in alkaline, reddish clayey alluvium. The Summit has formed in material weathered from limestone and soft limy shales. The Summit and Brewer soils differ from the Dennis in having a finer textured surface layer, a more clayey subsoil, and more calcium carbonate, as shown by concretions in the subsoil below about 30 inches. The nature of the parent materials from which these soils have been developing cause the differences.

Red-Yellow Podzolic soils

The Red-Yellow Podzolic soils in the county belong to the following series:

Dougherty.
Eufaula.
Stephenville.

These soils lie near the westernmost extent of the Red-Yellow Podzolic range, which covers the greater part of the southeastern United States. They are located in the Cross Timbers belt that extends from north-central Oklahoma to central Texas. They are detached from the main body of Red-Yellow Podzolic soils that extends eastward from eastern Oklahoma. In Oklahoma the rainfall is not sufficient to develop fully all of the characteristics of the Red-Yellow Podzolic soils.

The trees and grasses are mixed. The mature forests are somewhat open, and bluestem grasses cover the ground. The grasses modify the podzolic type of development that normally occurs under oak forest. The soils that develop are transitional toward the Reddish Prairie group. Normally the parent materials are slightly acid to medium acid. The leached A_2 horizon and the accumulative B_2 horizon are about as acid as the parent materials, or a little more acid. This similarity indicates that the amounts of basic materials removed from the soil have not been large.

Stephenville fine sandy loam, as observed in a profile in an undisturbed area 1 mile south of Cleveland, shows many of the characteristics of the Red-Yellow Podzolic great soil group:

A_0 Freshly fallen oak leaves and matted, partly decomposed leaves totaling 1 to 2 inches in thickness.

A_1 0 to 2 inches, grayish-brown (10YR 5/2; 3.5/2, moist) very fine sandy loam; weak medium granular structure; very friable; pH 6.5.

A_2 2 to 10 inches, light-brown (7.5YR 6/4; 5/4, moist) fine sandy loam; weak granular to massive structure; pH 6.5; a few small roots and a number of fine ones penetrate layer; short transition to the B_2 horizon.

B_2 10 to 28 inches, red (2.5YR 5/8; 4/6, moist) sandy clay; weak medium subangular blocky structure; slightly firm; moderately permeable; pH 5.5; hard when dry, slightly sticky when wet; a few fine sandstone fragments in the lower part; a few filled root channels and living roots ¼ to ½ inch in diameter penetrate layer; grades to C horizon.

C 28 to 36 inches, red (2.5YR 4/8; 4/6, moist) sandy clay loam streaked with shades of brown; contains thin layers of partly weathered soft sandstone; pH 5.5.

D 36 inches +, soft, brown sandstone; fine root hairs penetrate between the layers of sandstone and feed directly on the face of the rock; pH 6.0.

This profile was studied on a convex sloping ridge with a slope of 2 percent. There was a thick cover of young post and blackjack oaks and a few hickories. The ground not shaded by oaks had a bunchy stand of bluestem grasses and wild legumes.

Much of the Stephenville soil, as mapped in this county, is transitional toward the Bates and Zaneis soils of the Reddish Prairie group. Evidence of this transition is the

TABLE 11.—*Chemical and physical properties of*

Soil name and location	Sample No.[2 3]	Depth	Horizon	pH	Organic matter	Total N
		Inches			*Percent*	*Percent*
Dennis loam (SW¼SW¼SE¼ sec. 31, T. 21 N., R. 8 E.)	51–OK–59–34–1	0–6	A_{1p}	5. 8	2. 2	0. 103
	–1V	0–9	A_{11}	5. 8	4. 4	. 189
	–2V	9–18	A_{12}	5. 7	3. 1	. 134
	–3V	18–30	B_1	5. 8	1. 8	. 112
	–4V	30–44	B_2	6. 4	. 5	. 069
	–5V	44–52	B_3	6. 1	. 0	. 079
	–6V	52–70	C	6. 4	. 1	
Dennis loam (NW¼SW¼NW¼ sec. 25, T. 22 N., R. 6 E.)	51 OK–59–8–1V	0–8	A_1	5. 5	4. 7	. 170
	–1	0–8	A_{1p}	5. 4	2. 8	. 130
	–2	8–16	B_1	5. 4	2. 8	. 118
	–3	16–26	B_2	5. 8	1. 2	. 072
	–4	26–44	B_3	7. 0	. 7	. 015
	–5	44–60	C_1	7. 7	. 1	. 053
Bates fine sandy loam (NW¼ SW¼NE¼ sec. 3, T. 21 N., R. 6 E.)	51–OK–59–9–1	0–8	A_{1p}	5. 8	1. 1	. 060
	–1V	0–8	A_1	5. 7	2. 9	. 140
	–2V	8–20	B_1	5. 7	1. 9	. 093
	–3V	20–30	B_2	5. 3	1. 1	. 061
	–4V	30–44	C_1	5. 1	. 9	. 055
Summit clay loam (NE¼NE¼SE¼ sec. 6, T. 21 N., R. 6 E.)	51–OK–59–11–1V	0–9	A_1	6. 5	5. 6	. 220
	–1	0 9	A_{1p}	6. 4	3. 3	. 140
	–2	9–22	B	6. 4	2. 2	. 101
	–3	22–48	C	7. 4	. 8	. 171
Kirkland silt loam (NW¼NW¼NW¼ sec. 1, T. 22 N., R. 4 E.)	51–OK–59–24–1V	0–10	A_1	6. 3	4. 1	. 135
	–1	0–9	A_{1p}	6. 1	2. 9	. 090
	–2	9–17	B_{21}	6. 1	2. 4	. 106
	–3	17–30	B_{22}	6. 6	1. 2	. 034
	–4	30–42	B_3	7. 2	. 6	. 017
	–5	42–86	C	7. 8	. 4	. 027
Renfrow silt loam (SE¼NE¼NE¼ sec. 10, T. 22 N., R. 3 E.)	51–OK–59–23–1	0–12	A_{1p}	5. 8	2. 6	. 088
	–1V	0–12	A_1	5. 7	3. 4	. 128
	–2V	12–24	B_1	6. 7	2. 4	. 098
	–3V	24–36	B_2	7. 6	2. 9	. 070
	–4V	36–52	C	7. 6		. 033
Zaneis fine sandy loam (NE¼SW¼SW¼ sec. 9, T. 21 N., R. 4 E.)	51–OK–59–28–1	0–10	A_{1p}	5. 6	2. 4	. 099
	–1V	0–10	A_1	5. 9	3. 2	. 106
	–2V	10–18	B_1	5. 6	2. 1	. 074
	–3V	18–34	B_2	5. 7	1. 5	. 065
	–4V	34–42	C	6. 0	. 7	. 057
Norge silt loam (NW¼NW¼NW¼ sec. 5, T. 23 N., R. 5 E.)	51–OK–59–1–1	0–12	A_{1p}	5. 9	2. 2	. 090
	–1V	0–12	A_1	6. 2	3. 3	. 120
	–2V	12–20	B_2	5. 9	1. 8	. 106
	–3V	20–46	B_3	5. 8	1. 1	. 066
	–4V	46–72	C_1	5. 8	. 6	. 051
Norge fine sandy loam (NW¼SW¼SE¼ sec. 34, T. 22 N., R. 4 E.)	51–OK–59–15–1V	0–10	A_1	6. 0	3. 6	. 173
	–1	0–10	A_{1p}	5. 9	1. 5	. 074
	–2	10–18	B_1	5. 6	1. 7	. 133
	–3	18–42	B_2	6. 1	. 7	. 046
	–4	42–52	B_3 or C_1	6. 1	. 6	. 027
Vanoss silt loam (SW¼NW¼SW¼ sec. 1, T. 23 N., R. 5 E.)	51–OK–59–4–1V	0–14	A_1	6. 0	2. 6	. 110
	–1	0–14	A_{1p}	5. 9	2. 1	. 100
	–2	14–24	B_1	6. 1	1. 8	. 082
	–3	24–42	B_2	5. 9	1. 3	. 084
	–4	42–84	C	6. 5	. 5	. 057
Teller fine sandy loam (SE¼SW¼NW¼ sec. 5, T. 20 N., R. 9 E.)	51–OK–59–5–1V	0–10	A_1	5. 5	2. 7	. 080
	–1	0–10	A_{1p}	6. 5	1. 6	. 080
	–2	10–18	B_1	5. 9	1. 3	. 086
	–3	18–30	B_2	5. 8	1. 0	. 057
	–4	30–60	C	5. 6	. 7	. 049
Brewer silty clay loam (NE¼SW¼SW¼ sec. 29, T. 22 N., R. 5 E.)	51–OK–59–13–1	0–10	A_{1p}	5. 9	3. 5	. 148
	–2	10–26	B_2	6. 5	1. 8	. 061
	–3	26–46	B–C	7. 8	. 8	. 030
	–4	46–80	C	7. 4	. 3	. 017

[1] Data obtained with assistance from Oklahoma Soil Survey Project 567 under leadership of FENTON GRAY.

[2] Surface soil from cultivated area.

some soils of the Reddish Prairie great soil group[1]

Total P	Soluble P	Exchangeable cations			Sand	Silt	Clay	Organic carbon	Carbon-nitrogen ratio
		Capacity	K	Na					
Percent	*P. p. m.*	*Me/100gm.*	*Me/100gm.*	*Me/100gm.*	*Percent*	*Percent*	*Percent*	*Percent*	
0. 021	1. 6	17. 2	0. 56	0. 47					
. 020	1. 6	18. 6	. 46	. 17	25. 4	52. 3	22. 3	2. 31	12. 2
. 019	1. 6	22. 4	. 46	. 17	23. 9	43. 8	32. 3	1. 26	9. 4
. 016	. 0	24. 5	. 56	. 35	22. 4	40. 1	37. 5	. 67	6. 0
. 013	1. 6	17. 9	. 56	. 35	22. 6	39. 9	37. 5	. 38	5. 5
. 012	1. 6	21. 5	. 56	. 35	23. 8	40. 6	35. 6	. 23	2. 9
. 013	4. 8	18. 6			35. 4	35. 9	28. 7	. 13	
. 021	1. 6	18. 6	. 23						
. 022	. 0	15. 5	. 23						
. 020	. 0	20. 3	. 33						
. 014	. 0	26. 2	. 33						
. 011	. 0	25. 0	. 46						
. 023	. 0	21. 4	. 23						
. 013	3. 2	4. 5	. 46						
. 013	3. 2	9. 3	. 23						
. 017	. 0	6. 8	. 23						
. 015	. 0	9. 5	. 23						
. 014	. 0	13. 0	. 23						
. 031	6. 4	26. 2	. 33		28. 8	41. 1	30. 1	1. 54	7. 0
. 027	6. 4	24. 3	. 33						
. 017	. 0	27. 7	. 33		13. 8	42. 3	43. 9	. 57	5. 6
. 012	. 0	24. 4	. 23		12. 4	45. 1	42. 5	. 50	3. 0
. 022		19. 7	. 56						
. 014	. 0	20. 6	. 46	. 17	20. 4	52. 7	26. 9	1. 00	11. 1
. 013	. 0	27. 7	. 56	. 35	13. 1	50. 4	36. 5	. 67	6. 3
. 010	. 0	30. 5	. 77	. 35	12. 3	44. 7	43. 0	. 40	12. 0
. 009	. 0	30. 1	. 66	. 52	11. 2	46. 7	42. 1	. 19	11. 0
. 008	. 0	21. 9	. 56	. 52	13. 9	49. 3	36. 8	. 11	4. 1
. 015	. 0	15. 0	. 56						
. 018	. 0	18. 4	. 56		24. 3	55. 8	19. 9	1. 60	12. 5
. 013	. 0	10. 1	. 77		8. 8	36. 9	54. 3	. 83	8. 5
. 015	. 0	23. 0	. 56	6. 09	6. 7	40. 3	53. 0	. 45	6. 4
. 024	. 0	11. 2	. 33	2. 18	12. 7	48. 3	49. 0	. 18	5. 4
. 023	3. 2	9. 5	. 46						
. 017	3. 2	10. 2	. 46		54. 3	28. 1	17. 6		
. 016	. 0	11. 5	. 46		58. 5	18. 9	22. 6		
. 012	. 0	12. 8	. 46		41. 4	20. 5	38. 1		
. 010	. 0	11. 7			68. 0	15. 3	16. 7		
. 026	3. 2	11. 8	. 66		25. 8	50. 7			
. 018	3. 2	12. 7	. 23		25. 8	50. 7	23. 5	1. 78	14. 8
. 018	. 0	14. 7	. 56		21. 8	47. 5	30. 7	1. 46	13. 8
. 015	. 0	16. 7	. 33		16. 7	46. 7	36. 6	. 84	12. 7
. 012	. 0	16. 0	. 46		13. 9	52. 1	34. 1	. 14	2. 7
. 009	3. 2	8. 4	. 77		50. 6	37. 1	12. 3	. 61	3. 5
. 007	. 0	6. 0	. 56						
. 015	. 0	9. 0	. 33		41. 1	38. 6	20. 3	. 74	5. 6
. 013	. 0	10. 3	. 33		53. 3	30. 8	25. 9	. 35	7. 6
. 010	. 0	9. 7	. 46		57. 0	20. 7	22. 3	. 17	6. 3
. 023	1. 6	14. 2	. 56						
. 024	1. 6	14. 0	. 33		13. 9	69. 0	17. 1	. 94	8. 5
. 024	1. 6	15. 7	. 33		10. 9	64. 6	24. 5	. 98	11. 9
. 023		17. 0	. 33		7. 4	62. 2	30. 4	. 47	5. 6
. 021		14. 5	. 46		12. 6	59. 2	28. 2	. 17	3. 0
. 026	3. 2	8. 5	. 46		16. 6	67. 0	16. 4	. 94	11. 6
. 021	4. 8	8. 7	. 56						
. 019		11. 2	. 46		16. 2	58. 0	25. 8	. 95	11. 6
. 027		12. 7	. 33		13. 4	57. 4	29. 2	. 44	7. 7
. 016		10. 1	. 56		22. 5	50. 8	26. 7	. 21	4. 3
. 029	32. 0	21. 1	. 66		7. 0	66. 1	26. 9	1. 84	12. 4
. 019	32. 0	22. 3	. 46		5. 4	63. 4	31. 2	1. 22	20. 0
. 013	32. 0	25. 3	. 56	5. 39	7. 7	57. 6	34. 7	. 34	11. 3
. 015	32. 0	22. 8	. 56	1. 83	6. 5	56. 2	37. 3	. 16	9. 4

[1] Samples with "V" were taken from undisturbed native pasture.

deeper incorporation of humus, the darker upper subsoil horizon that has had less leaching, and a less acid reaction throughout the soil than is typical for Red-Yellow Podzolic soils.

DOUGHERTY soils are much like the Stephenville soil. Because they have developed in deep, soft sandy loam deposits, the Dougherty soils have a deeper solum, are leached more deeply, and have a much thicker A horizon. Also, as the Dougherty soils were developing from their parent material, there seems to have been a gradual addition of windblown sands from the nearby river beds. These additions seem to be continuing; consequently, the surface horizon varies in thickness and in some areas it is unaccountably deep.

EUFAULA soils have developed in deep, loamy sand deposits that contain very little fine material. They are easily penetrated by water. The B horizons, a sandy clay loam, are erratic in occurrence and thickness and are normally developed at depths greater than 36 inches. Like the Dougherty soils, the Eufaula soils seem to receive additions of windblown sands in some areas. This may account for the variation in thickness of the A horizon. The chemical and physical composition of Stephenville, Dougherty, and Eufaula soils are given in table 12.

Planosols

Soils of the Parsons series are the only members of the Planosols great soil group in the county.

These Planosols have a silty surface layer and a very compact, clayey subsoil. They have developed on moderately fine textured parent material on gentle slopes. They have slow surface and subsurface drainage. Typically they have a strongly bleached lower surface layer, but this feature is poorly developed in the few areas of true Planosols in Pawnee County. The physical and chemical characteristics of two profiles of Parsons soils are given in table 13.

PARSONS soil, as observed 7 miles east and 4½ miles south of Pawnee on an upland flat having a surface

TABLE 12.—*Chemical and physical composition of*

Soil name and location	Sample No.	Depth	Horizon	pH	Organic matter
		Inches			*Percent*
Stephenville fine sandy loam (NE¼NE¼SE¼ sec. 20, T. 21 N., R. 8 E.).	51–OK–59–18–1V*	0–2	A_1	7. 1	4. 3
	–2V	2–10	A_2	6. 9	1. 3
	–1	0–8	A_{1p}	6. 1	1. 2
	–2	8–24	B_2	5. 9	1. 1
	–3	24–32	C	6. 0	. 4
Dougherty fine sandy loam (SE¼SE¼SW¼ sec. 10, T. 20 N., R. 9 E.).	51–OK–59–22–1V	0–6	A_1	6. 6	2. 4
	–1	0–6	A_{1p}	5. 9	. 7
	–2	6–24	A_2	6. 9	. 6
	–3	24–40	B_2	6. 2	. 7
	–4	40–80	C	5. 9	. 3
Eufaula loamy fine sand (SW¼NE¼NE¼ sec. 15, T. 20 N., R. 9 E.).	51–OK–59–16–1V	0–6	A_1	----------	2. 0
	–1	0–4	A_{1p}	6. 5	1. 3
	–2	4–38	A_2	6. 7	. 3
	–3	38–46	B_2	5. 7	. 2
	–4	46–72	C	6. 2	. 2

*Samples with "V" were taken from undisturbed native pasture.

TABLE 13.—*Chemical and physical properties of two sample*

Soil name and location	Sample No.[1]	Depth	Horizon	pH	Organic matter	Total N
		Inches			*Percent*	*Percent*
Parsons silt loam (SE¼SW¼NW¼ sec. 28 T. 21 N., R. 6 E.).	51–OK–59–32–1	0–6	A_{1p}	5. 7	1. 6	0. 078
	–1V	0–13	A_1	6. 2	2. 7	. 120
	–2V	13–15	A_2	6. 1	2. 0	. 198
	–3V	15–26	B_{21}	6. 9	1. 4	. 152
	–4V	26–44	B_{22}	7. 6	. 7	. 065
	–5V	44–68	B_3	7. 5	0	. 049
	–6V	68–86	C	7. 8	0	. 034
Parsons silt loam (NW¼NE¼ sec. 19, T. 21 N., R. 7 E.).	51–OK–59–10–1V	0–10	A_1	5. 8	3. 0	. 110
	–1	0–10	A_{1p}	5. 8	2. 2	. 080
	–2	10–24	B_2	5. 9	2. 5	. 074
	–3	24–36	B_3	7. 1	1. 7	. 063
	–4	36–48	C	7. 6	. 9	. 025

[1] Surface soil from cultivated area.

gradient of 1 to 2 percent, shows the characteristics of the Planosols great soil group:

A_1 0 to 9 inches, dark grayish-brown (10YR 4/2; 3/2, moist) silt loam; weak medium granular structure; friable; moderately permeable; pH 6.1; weak tendency toward horizontal breakage.

A_2 9 to 11 inches, same as layer above except that the granules have coatings of light brownish gray (10YR 6/2) that are plainly visible only when the soil is nearly dry.

B_{21} 11 to 25 inches, dark grayish-brown (10YR 4/2; 2.5/2) clay specked with about 10 percent of reddish brown (5YR 4/4) and strong brown (7.5YR 5/6); weak medium blocky; very firm; very slowly permeable; pH 6.3; blocks are shiny, and material is very sticky when wet and very hard when dry; contains a few round black pellets; grades to the horizon below.

B_{22} 25 to 34 inches, dark grayish-brown (10YR 4/2; 3/2, moist) clay; 10 percent of surface specked or mottled with yellowish brown and reddish brown; weak coarse blocky; very firm; very slowly permeable; pH 6.8; blocks are shiny, and material is very sticky when wet and very hard when dry; contains a few round, black pellets, grades to the BC horizon below.

BC 34 to 50 inches, yellowish-brown (10YR 5.5/4; 4/5, moist) clay; 20 percent of surface mottled and streaked with light gray, strong brown, and reddish brown; shows seams of partly weathered sandstone and sandy shale; layer is firm, but much less firm than B_{21} and B_{22} above; dark-brown stains around the sandstone seams; contains a number of round black pellets; pH 7.2.

C 50 to 72 inches+, brown (8YR 5/3; 4/3, moist) clay shale mottled with strong brown and reddish brown; firm; contains thin seams of brown sandstone; alkaline (pH 8.0); calcareous in seams between the shale layers; a few large black pellets in upper part; lower part essentially unaltered clay shale.

This profile is in an undisturbed bluestem pasture. The grass cover is thrifty except in small saucer-shaped depressions or "buffalo wallows," where the stand of grasses is thin.

The bleached A_2 layer varies from 1 to 3 inches in thickness in the Parsons soils of this county. It is normally only faintly visible when the soils are moist.

Included in the nearly level areas of the Kirkland soils are small unmapped areas that are Planosols. These

some soils of the Red-Yellow Podzolic great soil group

Total N	Total P	Soluble P	Exchangeable cations		Sand	Silt	Clay	Organic carbon	Carbon-nitrogen ratio
			Capacity	K					
Percent	*Percent*	*P. p. m.*	*Me/100 gm.*	*Me/100 gm.*	*Percent*	*Percent*	*Percent*	*Percent*	
0. 129	0. 019	6. 4	11. 7	0. 46					
. 045	. 013	. 0	4. 8	. 23					
. 043	. 008	. 0	4. 3	. 23	58. 1	35. 0	6. 9	. 55	12. 8
. 053	. 012	. 0	12. 9	. 33	46. 3	24. 0	29. 7	. 56	10. 6
. 021	. 006	. 0	9. 6		69. 4	10. 1	20. 5	. 19	9. 1
. 080	. 015	8. 0	5. 1	. 66	73. 6	22. 7	3. 7	1. 30	16. 2
. 032	. 007	. 0	2. 0	. 56					
. 027	. 008	1. 6	2. 8	. 33	76. 2	17. 9	5. 9	. 18	6. 7
. 065	. 013	1. 6	12. 2	. 56	60. 6	19. 3	20. 1	. 24	3. 7
. 078	. 007	. 0	3. 8	. 33	87. 0	6. 3	7. 0	. 03	. 4
. 059	. 015	3. 2	4. 9	. 46					
. 043	. 009	1. 6	2. 4	. 33					
. 030	. 008	. 0	1. 4	. 23					
. 015	. 012	. 0	7. 3	. 46					
. 020	. 009	. 0	6. 9	. 33					

of Parsons silt loam from the Planosol great soil group

Total P	Soluble P	Exchangeable cations			Sand	Silt	Clay	Organic carbon	Carbon-nitrogen ratio
		Capacity	K	Na					
Percent	*P. p. m.*	*Me/100 gm.*	*Me/100 gm.*	*Me/100 gm.*	*Percent*	*Percent*	*Percent*	*Percent*	
0. 017	4. 8	16. 1	0. 33	0. 35					
. 014	1. 6	11. 1	. 56	. 35	17. 5	65. 5	17. 0	1. 55	12. 9
. 015	. 0	18. 3	. 33	. 87	14. 0	62. 9	23. 1	. 78	3. 9
. 012	1. 6	37. 8	. 61	3. 13	6. 8	46. 0	47. 2	. 44	2. 9
. 009	1. 6	33. 9	. 66	4. 00	12. 1	46. 3	41. 6	. 30	4. 6
. 013	1. 6	42. 4	. 56	4. 18	18. 0	39. 3	42. 7	. 10	2. 0
. 003	20. 8	43. 8		3. 31	12. 4	41. 1	46. 5		
. 018	3. 2	13. 4	. 23	. 52					
. 017	2. 0	12. 6	. 23	. 35					
. 016	. 0	36. 3	. 33	6. 35					
. 014	. 0	32. 3	. 46	13. 05					
. 012	. 0	30. 4	. 56	3. 65					

[2] Samples with "V" were taken from undisturbed native pasture.

areas have a dark-gray surface layer and a thin layer above the claypan that contains aggregates that have gray films. These included areas are of the Tabler series. They are slightly acid to neutral soils that have an alkaline subsoil. They contrast with the Parsons soils, which are medium to strongly acid throughout. A few areas of the Tabler soils have developed in what seems to be very old alluvium on gently sloping uplands. In a few small concave areas in this alluvium the bleached A_2 layer is 5 to 8 inches thick.

Most areas of Planosols in the county have developed in moderately fine textured material of neutral to alkaline reaction. The moisture effective in their formation is not great enough to carry the basic elements below the solum. Because of this, the lower subsoil in this area is normally more alkaline than in areas of the Parsons soils to the east and north.

Exchangeable sodium makes up one-fifth to one-tenth of the exchange capacity of the B_{22} and B_3 layers. It is moderately high in the parent material of the Parsons samples reported in table 13. Sodium has influenced the development of this soil and its characteristic claypan in a way not yet fully understood.

Solodized-Solonetz

In areas exposed to salts in solution, the normal soil-forming processes have been greatly modified and distinctive soils have developed. Such conditions often occur near the base of hills or in seepage spots on slopes. In these places, moisture is drawn to or seeps to the surface, and the salts concentrate after the moisture evaporates. On the alluvial bottom lands the same condition seems to develop. The moisture moves underground on the underlying clay shale; it is brought to the surface from temporary perched water tables by capillarity. In most places the areas affected by salts from underground water are round or elliptical.

Many kinds and combinations of salts concentrate, but sodium salts seem to be most active in this county. Where sodium salts are present, the soil clay is dispersed. This action breaks down the normal soil structure and allows the particles to run together. The physical condition therefore is undesirable. Organic matter is dispersed by the sodium in solution, and it moves down and darkens the subsoil.

Soils developed under the conditions just described are called Solodized Solonetz. They have thin, pale-brown silty layers of slightly acid to alkaline reaction overlying a very dark brown, blocky, slightly columnar clay subsoil that is moderately to strongly alkaline. These soils occur in many stages and degrees of development. Some are only 18 to 24 inches deep; others are deeper. In some areas the surface soil is acid.

In many places, the surface soil seems to be similar to the eroded surface soil of the Planosols. In Pawnee County the small areas of Solodized-Solonetz soils are called "slick spots," or in pasture areas they are called "buffalo wallows."

DRUMMOND very fine sandy loam as observed in a cultivated field, where it was associated with Brewer soils, has many characteristics of the Solodized-Solonetz great soil group. The field is on a high bottom of Camp Creek 5 miles southeast of Pawnee on a slope of about ½ percent.

- A_{1p} 0 to 5 inches, brown (10YR 5/3; 4/3, moist) very fine sandy loam to silt loam layered with very pale brown (10YR 7/3); strongly platy and vesicular in the upper 1 inch; grades into brown silt loam; weak granular structure; moderately permeable; pH 7.5; rests abruptly on layer below.
- B_{21} 5 to 9 inches, dark-brown (7.5YR 3/3; 2/2, moist) silty clay; coarse blocky structure; very firm; very sticky and plastic when wet; very slowly permeable; pH 8.0; layer is weakly columnar.
- B_{22} 9 to 18 inches, dark-brown (7.5YR 4/3; 3/3, moist) silty clay; moderate coarse blocky structure; very firm; very slowly permeable; pH 8.0.
- B_3 18 to 36 inches, dark-brown (7.5YR 4/3; 3/3, moist) silty clay; moderate medium subangular blocky structure; firm; slowly permeable; pH 8.0; grades to layer below.
- C_1 36 to 48 inches, reddish-brown (5YR 5/4; 4/4, moist) silty clay; same structure as the layer above; pH 8.0; contains a few calcium carbonate concretions and some round black pellets.
- C_2 48 to 72 inches, reddish-brown (5YR 5/4; 4/4, moist) silty clay; somewhat more friable and permeable than layer above; pH 8.0.

The profile is noncalcareous throughout. Surface drainage is very slow. The surface crusts badly. When it is dry, the crust seals the surface soil and prevents moisture from soaking into the profile. In contrast, the

TABLE 14.—*Physical and chemical analyses of a Solodized Solonetz*

Soil name and location	Sample No.	Depth	Horizon	pH	Organic matter	Total N	Total P	Soluble P
		Inches			*Percent*	*Percent*	*Percent*	*P. p. m.*
Drummond very fine sandy loam (SE¼SE¼SE¼ sec. 14, T. 21 N., R. 5 E.).	51-OK-59-2 -1[2]	0–5	A_{1p}	7. 7	0. 6	0. 030	0. 012	3. 2
	-2	5–9	B_{21}	7. 6	. 7	. 064	. 015	1. 6
	-3	9–18	B_{22}	7. 8	. 7	. 064	. 015	1. 6
	-4	18–36	B_3	8. 0	. 3	. 055	. 028	19. 2
	-5	36–48	C_1	8. 2	. 3	. 055	. 028	19. 2
	-6	48–72+	C_2	8. 2	. 4	. 044	. 032	32. 0
Brewer silty clay loam (NE¼NW¼ sec. 23, T. 21 N., R. 5 E.).	52-OK-59-41-1	0–9	A_1	6. 3	2. 4	. 104	. 160	----------
	-2	9–20	B_2	6. 7	1. 1	. 052	. 090	----------
	-3	20–36	B_3	7. 8	. 7	. 033	. 050	----------
	-4	36–62	C	8. 1	. 6	. 032	. 046	----------

[1] Data in part from unpublished thesis: Mehta, K. M. COMPARATIVE PHYSICAL AND CHEMICAL PROPERTIES OF A "SLICK SPOT" AND ADJOINING NORMAL SOIL OF THE REDDISH PRAIRIE SOIL AREA, 1954, Agronomy Department, Oklahoma A & M College.

surrounding Brewer soils have a dark, granular surface layer that absorbs water easily. Table 14 gives the chemical and physical data for Drummond and Brewer soils.

Many of the smaller areas designated on the map by spot symbols are less definitely developed than the soil described. On slopes in many places the bleached surface layer has been removed by water erosion. Thus, the tough plastic clay beneath is exposed. Normally, the supply of organic matter is low. It is difficult to work these soils into a seedbed. After a little rain, the surface slakes down and forms a whitish crust. Because they absorb water so slowly, these "slick spot" areas on side slopes are very susceptible to sheet erosion. Also, it is difficult to maintain terrace ridges on them.

Alluvial soils

The Alluvial soils of the county are of the following series:

Cleora.	Miller.
Dale.	Port.
Lela.	Yahola.

Alluvial soils vary greatly from place to place because of local variations in the sediments that make up their parent materials. These soils therefore vary in color, texture, and arrangement of layers. Because some of the streams are now deeply entrenched and overflow less frequently than they did formerly, there is great variation in the frequency of overflow and the age of the sediments. The soils on high areas of infrequently flooded alluvium are developing slowly. Consequently, the Alluvial soils on clayey sediments are developing characteristics similar to those of the Brewer soils. On the loamy alluvium, many areas of Port soil have characteristics similar to those of the Vanoss soil. Because it is older and has more organic matter, the Dale soil has a deeper A horizon than the soils of the Yahola series. The chemical composition of some Alluvial soils is given in table 15.

Lithosols

The Lithosols in Pawnee County are soils of these series:

Collinsville.	Sogn.
Darnell.	Talihina.
Lucien.	Vernon.
Pottsville.[1]	

[1] The Pottsville soil is not mapped separately in the county but is included in the Darnell-Talihina complex.

The Lithosols, or skeletal soils, consist of freshly and incompletely weathered rock. The soil covering is thin. The Lithosols are located mostly on steep slopes. In some places they occur on slight slopes where the rock is resistant to weathering or where the soil material is too new to have permitted development of a mature soil. Lithosols vary because of differences in underlying rock and in vegetation. The chemical composition of the Lithosols in the county is given in table 16.

Some Lithosols have developed under grass, and others under forest. The Vernon, Sogn, Talihina, Lucien, and Collinsville formed under grass, and the Darnell and Pottsville, under forest.

The Vernon soils formed on reddish calcareous clay and clay shale; the Sogn, on gray and olive limy shale and limestone; the Talihina, on gray and brown acid shale; the Collinsville, on gray and brown acid sandstone and siltstone; and the Lucien, on neutral, reddish, soft sandstone. These soils are formed in association with the Reddish Prairie soils.

LUCIEN fine sandy loam, as observed in an area 6 miles southwest of Pawnee, is typical of the Lithosols that occur in association with the Reddish Prairie soils:

A_1 0 to 6 inches, dark reddish-brown (5YR 4/4; 3.5/4, moist) fine sandy loam; weak granular structure; very friable; pH 5.8; grades to layer below.

AC 6 to 12 inches, dark reddish-brown (5YR 4/2; 3.5/2, moist) fine sandy loam; contains seams of light sandy clay loam and soft thinly bedded sandstone in the lower part; grades to layer below.

D 12 to 20 inches +, reddish-brown (2.5YR 5/3; 4/3, moist) soft, weakly cemented sandstone containing lenses of sandy clay loam and seams of silty clay shale; pH 6.3.

The profile was taken on a convex sloping ridge of about 6 percent. Elsewhere, in the same soil area, the slope ranges from 4 to 10 percent. There was a moderate cover of bluestems and grama grasses in the area, and also a few clumps of small post oaks and blackjack oaks. The Lucien soil is from 6 to 24 inches thick over sandstone; there is an occasional rock outcrop.

COLLINSVILLE soils are very similar to the Lucien soils, but they are brown and somewhat more loamy.

TALIHINA soils have a browner, finer textured, and more granular surface soil than the Lucien. Normally they have more free stone on the surface.

(Drummond) and the associated Reddish Prairie (Brewer) soils [1]

Exchangeable cations					Sand	Silt	Clay	Organic carbon	Carbon-nitrogen ratio
Capacity	Ca	Mg	K	Na					
Me/100 gm.	*Me/100 gm.*	*Me/100 gm.*	*Me/100 gm.*	*Me/100 gm.*	*Percent*	*Percent*	*Percent*	*Percent*	
10. 0	6. 6	2. 0	0. 23	4. 00	19. 9	63. 5	16. 6	0. 24	8. 0
23. 7	10. 5	2. 6	. 33	7. 31	8. 2	58. 9	32. 9	. 50	7. 8
23. 7	----------	----------	. 33	7. 31	6. 2	59. 5	34. 3	. 40	----------
21. 7	10. 4	3. 0	. 23	8. 09	8. 1	52. 2	39. 7	. 12	2. 2
21. 7	10. 4	3. 0	. 23	8. 09	9. 4	56. 7	33. 9	. 09	2. 2
23. 9	14. 3	4. 1	. 46	3. 30	12. 5	50. 7	36. 8	. 14	3. 2
----------	13. 0	2. 6	. 50	. 30	25. 5	46. 0	28. 5	----------	----------
----------	16. 1	4. 0	. 40	. 40	24. 5	39. 0	36. 5	----------	----------
----------	15. 0	4. 1	. 30	. 60	22. 5	39. 0	38. 5	----------	----------
----------	13. 7	4. 3	. 30	2. 60	17. 5	40. 0	42. 5	----------	----------

[2] Surface soil from cultivated area.

TABLE 15.—*Chemical and physical properties of some soils of the Alluvial great soil group*

Soil name and location	Sample No.	Depth	Horizon	pH	Organic matter	Total N	Total P	Soluble P	Exchangeable cations			Se
									Capacity	K	Na	
		Inches			*Percent*	*Percent*	*Percent*	*P. p. m.*	*Me/100 gm.*	*Me/100 gm.*	*Me/100 gm.*	*Pe*
Yahola fine sandy loam (NE¼NE¼SE¼) sec. 9, T. 21 N., R. 8 E.	51-OK-59-6-1	0-10	A	7.4	0.9	0.050	0.035	32.0	5.4	0.33		
	-2	10-22	A-C	7.4	1.3	.042	.031	32.0	6.8	.33		
	-3	22-60	C	7.7	.2	.009	.021	32.0	2.5	.10		
Yahola fine sandy loam (SE¼NW¼NW¼ sec. 27, T. 20 N., R. 9 E.)	51-OK-59-12-1	0-14	A	7.4	1.2	.050	.026	32.0	6.2	.56		
	-2	19-60	A-C	7.1	.1	.032	.015	32.0	4.3	.23		
Yahola silt loam (SE¼SE¼SE¼ sec. 16, T. 21 N., R. 8 E.)	51-OK-59-3-1	0-14	A_1	6.9	.5	.090	.040	32.0	7.4	.56		
	-2	14-26	C_1	7.0	.8	.061	.033	32.0	10.6	.33		
	-3	26-60	C_2	7.7	.3	.034	.028	32.0	5.5	.23		
Port silt loam (SW¼NW¼NW¼ sec. 32, T. 22 N., R. 5 E.)	51-OK-59-14-1	0-10	A_{11}	6.5	1.9	.078	.009	28.8	10.9	.46		
	-2	10-28	A_{12}	6.4	1.6	.034	.009	9.6	14.6	.33		
	-3	28-60	C	6.2	1.3	.068	.009	8.0	18.0	.46		
Miller clay (NW¼SE¼NE¼ sec. 16, T. 21 N., R. 8 E.)	51-OK-59-30-1	0-8	A_{11}	7.3	2.4	.111	.052	32.0	25.6	1.22	0.52	
	-2	8-20	A_{12}	7.3	2.2	.131	.050	32.0	23.0	1.02	.61	
	-3	20-36	A-C	7.5	1.7	.089	.053	32.0	23.7	.82	1.40	
	-4	36-52	C_1	7.5	1.0	.080	.046	32.0	17.4	.56	1.22	
	-5	52-78	C_2	7.7	.4	.025	.019		5.7	.23	.87	
Lela silty clay loam (SW¼NE¼NW¼ sec. 31, T. 22 N., R. 4 E.)	51-OK-59-31-1	0-16	A_{11}	6.2	2.2	.077	.021	.0	16.9	.46	.00	
	-2	16-24	A_{12}	6.0	1.7	.065	.017	.0	20.6	.46	.17	
	-3	24-32	A-C	6.0	1.9	.137	.015	.0	21.6	.56	.17	
	-4	32-48	C_1	6.2	1.1	.074	.014	.0	26.0	.56	.52	
	-5	48-80	C_2	7.3	.4	.076	.024	32.0	26.1	.77	.52	
Cleora fine sandy loam (SE¼NE¼NW¼ sec. 17, T. 21 N., R. 8 E.)	51-OK-59-29-1	0-18	A_{11}	6.0	.9	.043	.023	1.6	5.3	.23		
	-2	18-30	A_{12}	5.9	.8	.002	.018	1.6	6.5	.23		
	-3	30-46	A-C	6.1	.5	.055	.016	1.6	6.2	.33		
	-4	46-80	C	5.9	.6	.038	.019	1.6	17.8	.46		
Dale silt loam (SE¼SE¼NE¼ sec. 5, T. 21 N., R. 8 E.)	51-OK-59-7-1	0-30	A	7.0	1.1	.040	.028	32.0	6.1	.33		62
	-2	30-50	A-C	6.8	.7	.042	.013	30.4	6.8	.33		55
	-3	50-80	C	6.5	.3	.028	.026	12.8	8.0	.10		39

TABLE 16.—*Chemical composition of some soils of the Lithosol great soil group*

Soil name and location	Sample No.	Depth	Horizon	pH	Organic matter	Total N	Total P	Soluble P	Exchangeable cations	
									Capacity	K
		Inches			*Percent*	*Percent*	*Percent*	*P. p. m.*	*Me/100 gm.*	*Me/100 gm.*
Sogn stony clay loam (NE¼SE¼NE¼ sec. 7, T. 21 N., R. 6 E.)	51-OK-59-25-1	0-5	A	7.4	6.1	0.277	0.042	32.0	34.9	0.66
	-2	5-22	C	7.5	3.3	.272	.048	6.4	27.0	.33
Talihina silty clay loam (NE¼NE¼ NW¼ sec. 34, T. 21 N., R. 8 E.)	51-OK-59-20-1	0-6	A	5.6	5.5	.211	.028	3.2	20.0	.33
	-2	6-16	A-C	5.1	2.8	.127	.022	.0	23.8	.23
	-3	16-30	C	5.2	1.7	.137	.018	.0	25.1	.23
Collinsville loam (SE¼SE¼NE¼ sec. 34, T. 21 N., R. 7 E.)	51-OK-59-17-1	0-8	A	6.0	3.6	.130	.020	1.6	15.8	.46
	-2	8-30	C	6.6	.8	.034	.010	1.6	10.4	.23
Lucien fine sandy loam (NE¼NE¼ NW¼ sec. 21, T. 21 N., R. 4 E.)	51-OK-59-27-1	0-5	A	5.7	2.2	.045	.012	3.2	7.3	.56
	-2	5-15	A-C	5.5	1.1	.051	.013	.0	13.5	.33
	-3	15-24	C	6.2	.4	.011	.008	.0	4.3	.23
Darnell fine sandy loam (NE¼NW¼ NE¼ sec. 33, T. 21 N., R. 8 E.)	51-OK-59-19-1	0-4	A	6.7	2.1	.063	.018	6.4	4.9	.46
	-2	4-18	A-C	6.4	.4	.013	.013	.0	2.6	.23
	-3	18-24	C	5.4	.0	.055	.006	.0	3.2	.10
Pottsville loam (NW¼SW¼NW¼ sec. 16, T. 21 N., R. 8 E.) [1]	51-OK-59-26-1	0-4	A	5.8	2.9	.085	.023	3.2	10.3	.33
	-2	4-13	A-C	5.2	.8	.002	.014	.0	7.6	.46
	-3	13-24	C	5.1	.6	.002	.012	.0	15.0	.33

[1] Pottsville soil not mapped separately in the county but included with the Darnell-Talihina complex.

TABLE 17.—*Some chemical characteristics of Minco soils of the Regosol great soil group*

Soil name and location	Sample No.	Depth	Horizon	pH	Organic matter	Total N	Total P	Soluble P	Exchangeable cations	
									Capacity	K
		Inches			*Percent*	*Percent*	*Percent*	*P. p. m.*	*Me/100 gm.*	*Me/100 gm.*
Minco soils (NE¼NW¼NW¼ sec. 27, T. 20 N., R. 9 E.)	51-OK 59-21-1	0-12	A	6.4	0.4	0.014	0.013	3.2	2.6	0.10
	-2	12-50	A-C	6.6	.2	.009	.008	3.2	1.5	.10
	-3	50-80	C	6.7	.1	.006	.007	1.6	.7	.86

SOGN soils are normally moderately stony and have flags and chips of limestone and limy shale on the surface. The Sogn surface soil is alkaline.

VERNON soils have an alkaline, reddish, granular, fine-textured surface soil. They overlie clay and clay shale and in many places are closely associated with the Lucien soils.

DARNELL and POTTSVILLE soils are Lithosols under an oak cover. The Darnell soils have developed in slightly to medium acid sandstone, and the Pottsville, in silty and clayey shale.

A profile of Darnell fine sandy loam, in an area about 5 miles southeast of Skedee, is typical of a Lithosol under forest and on soft sandstone:

A_1 0 to 2 inches, grayish-brown (10YR 5/1.5; 3/1.5, moist) light fine sandy loam; structureless; very friable; pH 6.0; grades to layer below.

A_2 2 to 12 inches, pale-brown (10YR 6/3; 5/3, moist) light fine sandy loam; very friable; seams of partly weathered soft sandstone in the lower part; slightly more reddish cast where layer grades to the layer below; pH 6.0.

D 12 to 20 inches +, brown (7.5YR 5/4; 4/4, moist) soft sandstone; seams of light sandy clay loam and fine sandy loam in upper part; pH 6.0; more massive and somewhat harder in lower part.

This soil occupies a narrow, convex sloping rim of a sandstone outcrop on a slope of about 4 percent. It is surrounded by larger areas of the shale that underlies the Dennis and Bates soils of the Reddish Prairie great soil group. There is a moderately thick cover of blackjack and post oaks, and a very thin ground cover of bluestems and three-awn grasses. This area is used for pasture.

The Pottsville soils have a thin, darkened surface layer. The bleached loamy lower layers overlie brownish, mottled silt and clay shale. In many places they have a thin cover of sandstone slabs. Pottsville soils are on slopes ranging from 6 to 15 percent.

In comparing profiles, it is apparent that the A_1 horizon of the Darnell is much thinner than that of the Lucien soils. Also, there is no evidence that organic matter has accumulated in the lower part of the A_2 horizon in the Darnell. The horizons of the Lucien soils are noticeably darkened by organic matter and are more granular than those of the Darnell. The differences in these two profiles are almost entirely caused by the effects of vegetation, as they are both from similar sandstone. The profiles of both show no marked difference in reaction, so it would appear that neither is greatly leached.

Regosols

MINCO soils are Regosols; that is, very youthful soils developing in unconsolidated deposits. The chemical properties of the Minco soils are given in table 17. A profile of a Minco soil taken on the mantled upland above

the flood plain of the Cimarron River about 3½ miles northwest of Keystone is as follows:

A_1 0 to 10 inches, brown (7.5YR 5/3; 4/3, moist) very fine sandy loam; weak granular structure; very friable; pH 6.5; grades to layer below.

C_1 10 to 40 inches, light-brown (7.5YR 6.5/3; 6/3, moist) very fine sandy loam; very friable; pH 6.5.

C_2 40 to 60 inches +, reddish-brown (5YR 5/4; 4/5, moist) very fine sandy loam; very friable; pH 6.5; material is even in texture but has thin bands of yellowish-red silt loam in lower part.

The profile was taken on the bench about 20 feet above the Cimarron River, where the undulating slopes range from 2 to 5 percent. Small amounts of windblown material from the river channel were probably added to the profile from time to time. The native cover is a thin stand of annual grasses and bluestem. The Minco soils lie a few feet above areas of Dale silt loam, an Alluvial soil. They are something like the Dale, but have a shallower, less dark surface soil and more wavy relief. No texture profile has developed in the Minco soils. They consist of a darkened surface layer formed under grasses and overlying physically unaltered materials. The Regosols are similar to the Lithosols in their stage of development; their youthfulness can be attributed to the recent accumulation of the parent material. The Lithosols, in contrast, stay young because they are on steep slopes. The forces of erosion remove the soil material as it is formed from the rocks, so it is not possible for a deep solum to form.

Some of the Vernon soils are Regosols, but they are included with the Lithosols because their parent rocks are mixed soft clay beds and shaly clays. Resistant sandstones are locally interbedded with these clayey rocks.

Soil Survey Methods and Definitions

The scientist who makes a soil survey examines soils in the field, classifies them in accordance with facts that he observes, and maps their boundaries on an aerial photograph or other map (*10*).

Field Study.—The soil surveyor bores or digs many holes to see what the soils are like. The holes are not spaced in a regular pattern, but are located according to the lay of the land. Usually they are not more than a few hundred feet apart, but sometimes they are much closer. In most soils such a boring or hole reveals several distinct layers, called horizons, which collectively are known as the soil profile. Each layer is studied to see how it differs from others in the profile and to learn the things about this soil that influence its capacity to grow plants.

Color is usually related to the amount of organic matter. The darker the surface soil, as a rule, the more organic matter it contains. Streaks and spots of gray, yellow, and brown in the lower layers generally indicate poor drainage and poor aeration. Colors are given in descriptive terms, such as "dark grayish brown." They are noted by a symbol in the Munsell color chart—a national color standard. For example, 10YR 4/2 corresponds to the descriptive term, "dark grayish brown." The notation 10YR 4/2 is a standard color reference in the Munsell chart.

Texture, or the content of sand, silt, and clay is determined by the way the soil feels when rubbed between the fingers, and it is later checked by laboratory analysis. Texture determines how well soil retains moisture, plant nutrients, and fertilizer, and whether it is easy or difficult to cultivate; terms used for texture classes are sand, loamy sand, sandy loam, loam, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay.

Structure, which is the way the individual soil particles are arranged in larger grains, and the amount of pore space between grains, gives us clues to the ease or difficulty with which the soil is penetrated by plant roots and by moisture.

Consistence, or the tendency of the soil to crumble or to stick together, indicates whether it is easy or difficult to keep the soil open and porous under cultivation.

Other characteristics observed in the course of the field study and considered in classifying the soil include the following: The depth of the soil over bedrock, over cemented or compact layers, or over layers of loose gravel; the presence of gravel or stone in amounts that will interfere with cultivation; the steepness and pattern of slopes and the degree of erosion; the runoff of surface water, drainage through the soil, and occurrence of a high ground water table; the nature of the underlying rocks or other parent material from which the soil has developed; and the acidity or alkalinity of the soil as measured by chemical tests.

Classification.—On the basis of the characteristics observed by the survey team and supplemented by laboratory tests, soils are classified into phases, types, and series. The soil type is the basic classification unit. A soil type may consist of several phases. Types that resemble each other in most of their characteristics are grouped into soil series.

Soil type.—Soils similar in kind, thickness, and arrangement of soil layers are classified as one soil type. They have textural names such as fine sandy loam, loam, or clay loam.

Soil phase.—Because of differences other than those of kind, thickness, and arrangement of layers, some soil types are divided into two or more phases. Slope variations, frequency of rock outcrops, degree of erosion, depth of soil over the substratum, type of drainage (natural or artificial), and presence of excess soluble salts are examples of characteristics that suggest dividing a soil type into phases.

The soil phase (or the soil type if it has not been subdivided) is the unit shown on the soil map. It is the unit that has the narrowest range of characteristics. Use and management practices therefore can be specified for the soil phase more easily than for soil series or yet broader groups that contain more variation.

Soil series.—Soils which are similar in all important characteristics except for texture of the surface horizon belong to the same series. In a given area it frequently happens that a soil series is represented by only one soil type. Each series is named for a place near which the soil was first mapped. Thus soils of the Lela series are alluvial soils named for the town of Lela.

Miscellaneous land types.—Fresh stream deposits or rough, stony, and severely gullied areas that have little true soil are not classified into types and series but are identified by descriptive names. Mixed alluvial land and

sandy alluvial land are miscellaneous land types in Pawnee County.

Soil complex.—When two or more soils are so intricately associated in small areas that it is not practical to show them separately on the soil map, they are mapped together and called a soil complex. The Brewer-Drummond complex is a complex of Brewer and Drummond soils.

Great soil group.—A broad group of soils having common internal soil characteristics. Examples are Reddish Prairie soils, Lithosols, and Regosols. The great soil groups fall within three orders—zonal, intrazonal, and azonal.

ADDITIONAL TERMS.—Other terms used in this survey that may not be familiar are defined as follows:

Acid. High in exchangeable hydrogen and having a reaction of pH 6.5 or below. *Slightly acid,* pH 6.1–6.5; *medium acid,* pH 5.6–6.0; *strongly acid,* pH 5.1–5.5; *very strongly acid,* pH 4.5–5.0.

Alluvium. Sediments deposited by streams; sediments may be homogeneous and of purely local origin, or they may be mixed, as those along major streams.

Blocky. Many-sided peds bounded by flat or rounded surfaces, which have been shaped by the faces of the surrounding peds; roughly blocklike. *Subangular blocky* means many-sided peds that have mixed rounded and plane faces and mostly rounded vertices; subangular blocky is somewhere between blocky and granular.

Calcareous. Containing free carbonates. Effervesces on application of dilute hydrochloric acid.

Climax vegetation. The combination of plants that grew originally on a site.

Colluvium. Soil material accumulated at the foot of strong slopes through the action of gravity, frost, soil or local wash; material normally is not sorted.

Columnar. Many-sided peds bounded by flat or nearly flat surfaces; peds are longer in the vertical axis than the horizontal and have rounded caps.

Concave. Land surfaces curved like the interior of a circle or hollow sphere. Concave spots on level land may be dished, or swalelike.

Concretions. Rounded and hardened masses of mineral matter formed as concentric rings around a central particle; concretions form from calcium carbonate, iron-manganese, and so on.

Convex. Land surfaces that resemble a segment of a sphere viewed from the outside.

Ferruginous. Iron-bearing, as applied to dark concretions, films, and spots in soils.

Firm. Soil material that crushes under moderate pressure between thumb and forefinger; resistance distinctly noticeable. *Very firm* soil material crushes under strong pressure. *Extremely firm* material cannot be crushed between thumb and forefinger and must be broken apart bit by bit.

Friable. Soil material easily crushed under gentle to moderate pressure between thumb and forefinger; coheres when pressed together. *Very friable* soil material crushes under very gentle pressure and coheres slightly when pressed together.

Granular. Rounded peds bounded by curved or very irregular surfaces that do not accommodate with the adjoining peds.

Loose. Noncoherent when slightly moist, even when pressed together.

Massive. No observable structure, but material is coherent when pressed together.

Munsell color notation. A method of designating soil color by a combination of letters and numbers, such as 5YR 3/4. Use of the Munsell notation is explained in the Soil Survey Manual (*10*).

Neutral. Exchangeable hydrogen and bases are about equal; pH 6.6–7.3.

Peds. Natural groupings of soil particles into characteristic forms; that is, granules, prisms, blocks, or plates.

Permeable. Permits easy penetration of air and water.

Pinholes. Very fine holes in soil that increase porosity.

Porous. Applied to a soil without observable structure that is coherent and contains many pores, or pinholes.

Prismatic. Many-sided peds bounded by flat or almost flat surfaces; peds are longer in vertical axis than horizontal and have flat tops.

Single grain. A term applied to loamy sands and sands that do not contain enough silt and clay to bind the sand into definite structural peds.

Subsoil. The B horizon, or zone of accumulation, in soils that have a distinct profile. The subsoil is normally more clayey than the layer above and ordinarily is 8 to 16 inches below the surface. The *upper subsoil* is that part of the subsoil that lies between the darkened A horizon and the more clayey subsoil layer below. The upper subsoil is also known as the B_1 horizon, or transitional horizon.

Substratum. Layer of material beneath the soil profile from which the soil developed or on which it rests.

Surface soil. The part of a soil ordinarily stirred in tillage, or its equivalent in uncultivated soil. The surface soil normally is 5 to 8 inches of darkened soil material in the upper part of the soil; it is also termed the A horizon. The *subsurface soil* is that part of the darkened upper part of a soil just below the surface soil.

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Areas surveyed in Oklahoma shown by shading.

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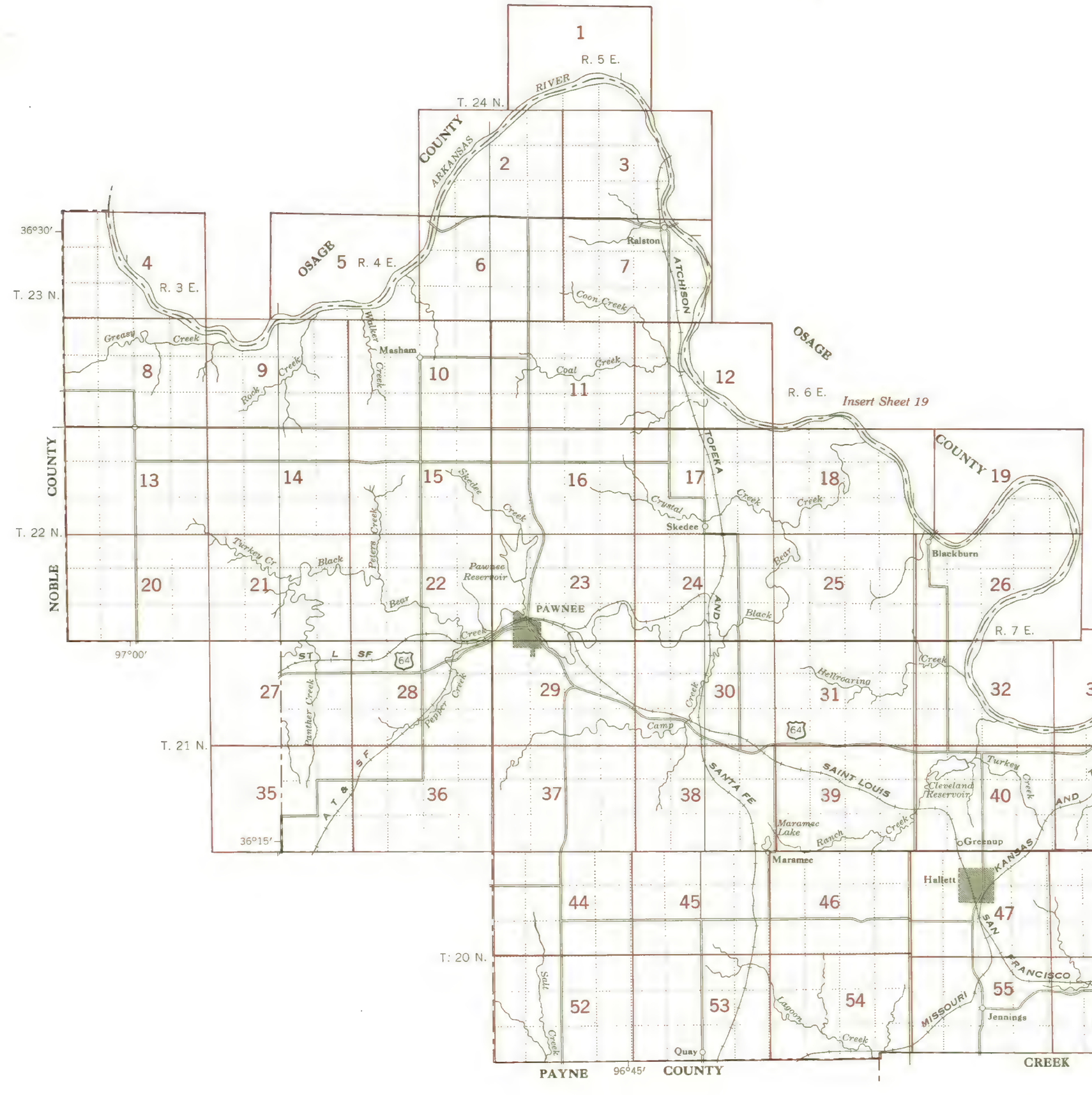
INDEX TO MAP SHEETS
PAWNEE COUNTY, OKLAHOMA



SOILS LEGEND

SYMBOL	NAME
Ba	Bates fine sandy loam, 2-5 percent slopes
Bb	Brewer silty clay loam
Bc	Brewer-Drummond complex
Ca	Cleora fine sandy loam
Da	Dale silt loam
Db	Darnell soils, 3-8 percent slopes
Dc	Darnell-Talihina complex, 8-45 percent slopes
Dd	Dennis loam, 2-5 percent slopes
De	Dennis loam, eroded, 3-5 percent slopes
Dg	Dennis complex, 5-8 percent slopes
Dh	Dennis complex, severely eroded, 3-8 percent slopes
Dk	Dougherty fine sandy loam, 2-5 percent slopes
Dl	Dougherty fine sandy loam, 5-8 percent slopes
Dm	Dougherty and Eufaula soils, 8-15 percent slopes
Ea	Eufaula loamy fine sand, 1-4 percent slopes
Eb	Eufaula loamy fine sand, 4-8 percent slopes
Ka	Kirkland silt loam, 0-1 percent slopes
Kb	Kirkland silt loam, 1-3 percent slopes
Kc	Kirkland silt loam, eroded, 1-3 percent slopes
La	Lela soils
Ma	Miller clay
Mb	Minco soils, 2-5 percent slopes
Mc	Mixed alluvial land
Na	Norge fine sandy loam, 2-5 percent slopes
Nb	Norge silt loam, 2-5 percent slopes
Nc	Norge silt loam, 5-8 percent slopes
Nd	Norge soils, severely eroded, 3-8 percent slopes
Pa	Parsons complex, 1-3 percent slopes
Pb	Parsons complex, eroded, 1-3 percent slopes
Pc	Port silt loam
Ra	Renfrow silt loam, 1-3 percent slopes
Rb	Renfrow silt loam, 3-5 percent slopes
Rc	Renfrow silt loam, eroded, 3-5 percent slopes
Rd	Renfrow soils, severely eroded, 3-5 percent slopes
Sa	Sandy alluvial land
Sb	Sogn, Talihina, and Collinsville soils, 3-20 percent slopes
Sc	Stephenville fine sandy loam, 2-5 percent slopes
Sd	Summit clay loam, 3-5 percent slopes
Ta	Teller and Dougherty soils, severely gullied, 3-8 percent slopes
Tb	Teller soils, 2-5 percent slopes
Tc	Teller soils, 5-10 percent slopes
Va	Vanoss silt loam, 0-2 percent slopes
Vb	Vernon and Lucien soils, 5-15 percent slopes
Ya	Yahola silt loam
Yb	Yahola fine sandy loam
Za	Zaneis soils, 2-5 percent slopes
Zb	Zaneis soils, severely eroded, 3-8 percent slopes

Soils surveyed 1947-52 by H. M. Galloway, U. S. Department of Agriculture and Oklahoma Agricultural Experiment Station, and Wm. Bagley, Robert B. Kehrein, and Emory Tower, U. S. Department of Agriculture.
Correlation by E. H. Templin, U. S. Department of Agriculture.

Soil map constructed by Cartographic Division, Soil Conservation Service, USDA, from 1954 aerial photographs. Controlled mosaic based on polyconic projection, 1927 North American datum.

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Roads
- Good motor
- Poor motor
- Trail
- Marker, U. S. (33)

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail, foot
- Railroad
- Ferry
- Ford
- Grade
- R. R. over
- R. R. under
- Tunnel

Buildings
- School
- Church
- Station

Mine and Quarry
- Shaft
- Dump
- Prospect

Pits, gravel or other

Power line

Pipeline

Cemetery

Dam

Levee

Tank

Oil well

Sawmill

Canal lock (point upstream)

BOUNDARIES

- National or state
- County
- Township, civil
- U. S.
- Section
- City (corporate)
- Reservation
- Land grant

DRAINAGE

Streams
- Perennial
- Intermittent, unclass.
- Crossable with tillage implements
- Not crossable with tillage implements

Canals and ditches (CANAL / DITCH)

Lakes and ponds
- Perennial
- Intermittent

Wells (flowing)

Springs

Marsh

Wet spot

RELIEF

Escarpments
- Bedrock
- Other

Prominent peaks

Depressions (Large / Small)
- Crossable with tillage implements
- Not crossable with tillage implements
- Contains water most of the time

SOIL SURVEY DATA

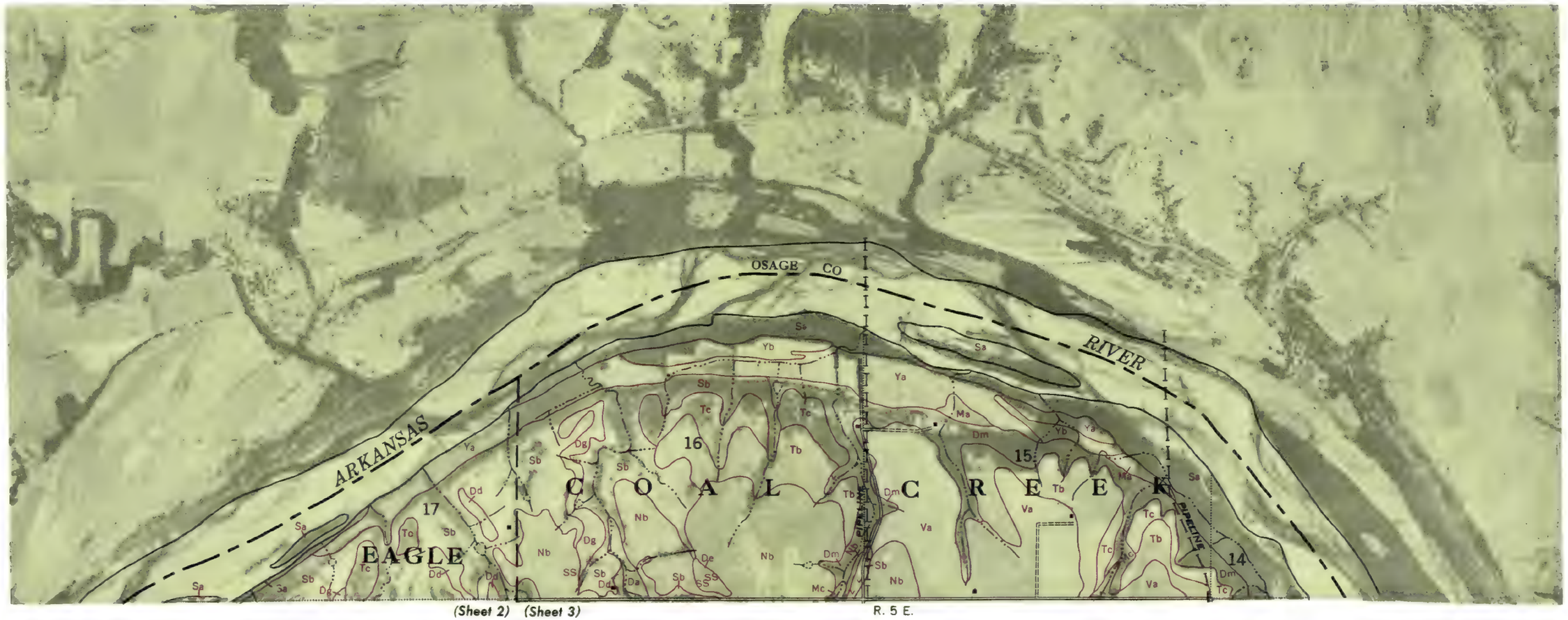
- Soil type outline and symbol (Dx)
- Gravel
- Stones
- Rock outcrops
- Chert fragments
- Clay spot
- Sand spot
- Slick spot
- Oil waste spot (#)

Erosion
- Uneroded spot (U)
- Sheet, moderate (S)
- Sheet, severe (SS)
- Gully, moderate (G)
- Gully, severe (GG)
- Sheet and gully, moderate (SG)
- Wind, moderate
- Wind, severe
- Blowout
- Wind hummock
- Overblown soil

Gullies
- Crossable with tillage implements
- Not crossable with tillage implements

Areas of alkali and salts (A / M / S)
- Strong
- Moderate
- Slight
- Free of toxic effect (F)
- Sample location (● 26)
- Saline spot

N



0 ½ 1 Mile

Scale 1:20000

0 5000 Feet

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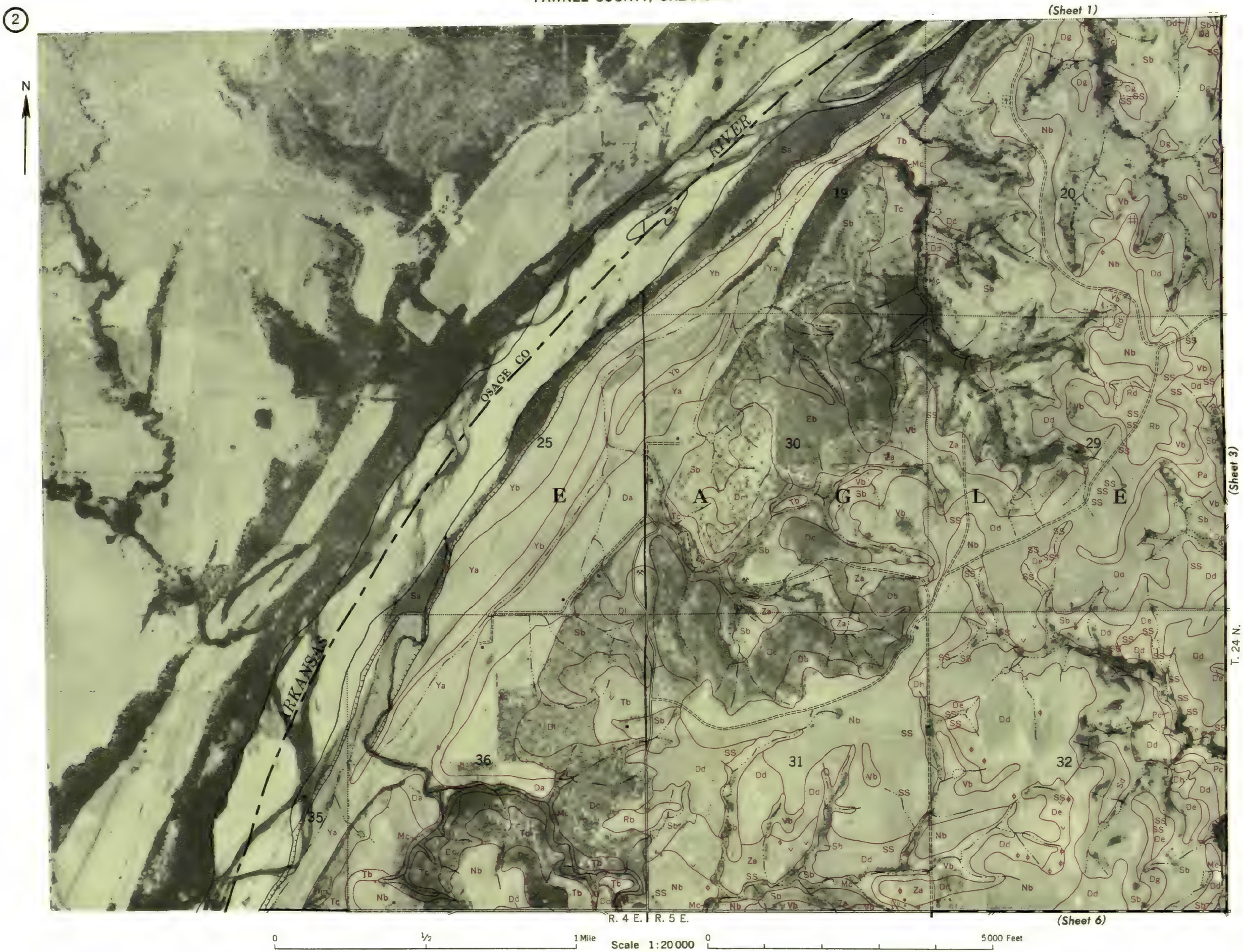
(Sheet 1)
(Sheet 3)
(Sheet 6)
N
OSAGE CO
RIVER
ARKANSAS
E A G L E
19
20
25
29
30
31
32
35
36
T. 24 N.
R. 4 E. | R. 5 E.
0
½
1 Mile
Scale 1:20 000
0
5000 Feet

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4
NOBLE CO
R. 3 E.
N
T. 23 N.
NOBLE CO
ARKANSAS
RIVER
OSAGE CO
RED ROCK
CREEK
PIPELINE
O T O E
6
5
7
8
18
17
16
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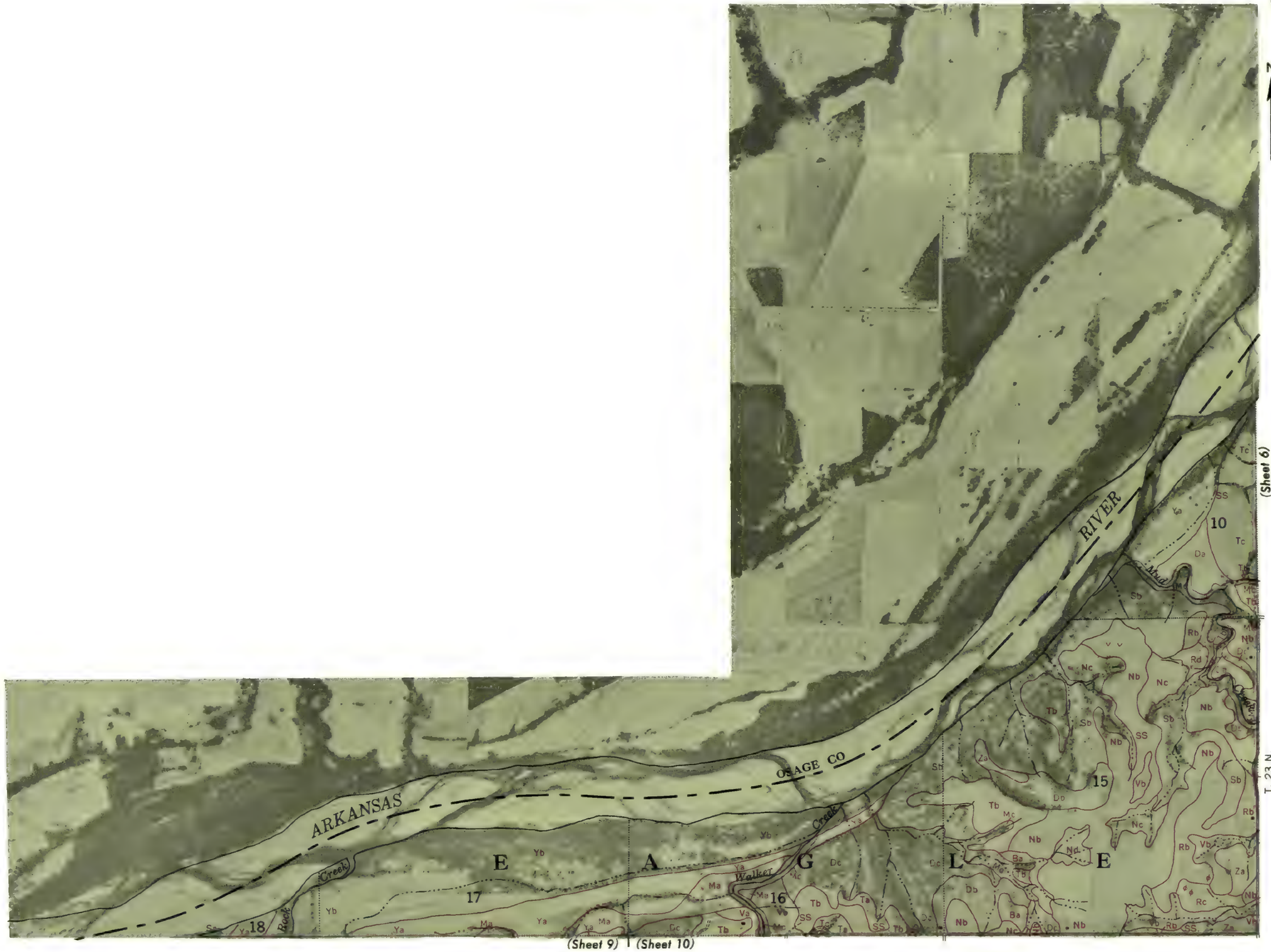
PAWNEE COUNTY, OKLAHOMA

5



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PAWNEE COUNTY, OKLAHOMA

R. 4 E. | R. 5 E.

(6)

(Sheet 2)

N

OSAGE CO

ARKANSAS RIVER

Fairview School

E A G L E

C O A L

C R E E K

(Sheet 5)

(Sheet 7)

T. 23 N.

(Sheet 10) | (Sheet 11)

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet

PAWNEE COUNTY, OKLAHOMA

(Sheet 3)

R. 5 E.

7

N

T. 23 N.

(Sheet 6)

Ralston

Pleasant Valley School

Eagle Creek

Coon Creek

ARKANSAS RIVER

OSAGE CO.

PIPELINE

ATCHISON TOPEKA AND SANTA FE TRANSMISSION LINE

POWER

RALSTON CEMETERY

COALCREEK

(Sheet 11) (Sheet 12)

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet

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PAWNEE COUNTY, OKLAHOMA

(8)

(Sheet 4)

R. 3 E.

OSAGE CO

ARKANSAS RIVER

N

NOBLE CO

T. 23 N.

(Sheet 9)

(Sheet 13)

0 ½ 1 Mile

Scale 1:20 000

0 5000 Feet

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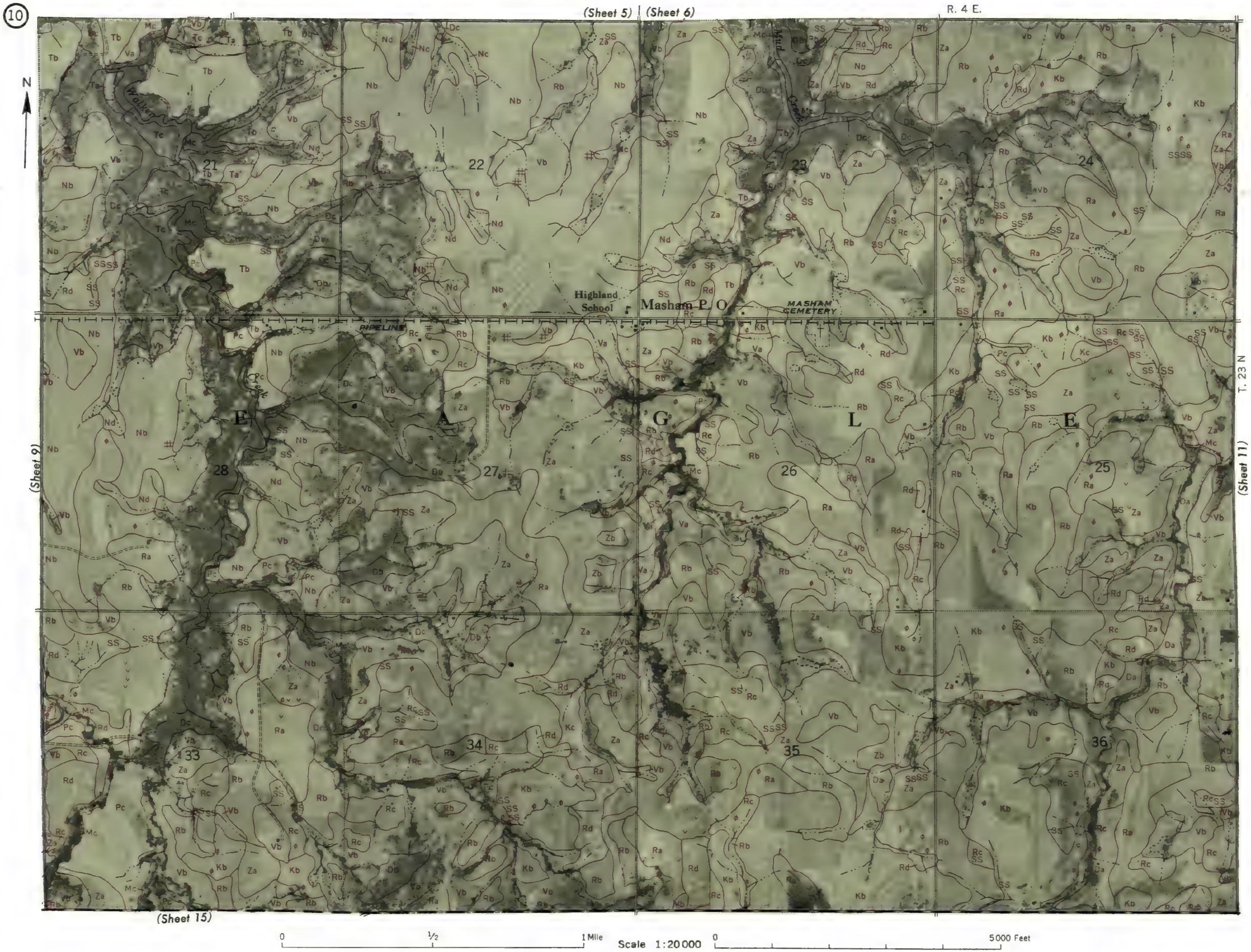
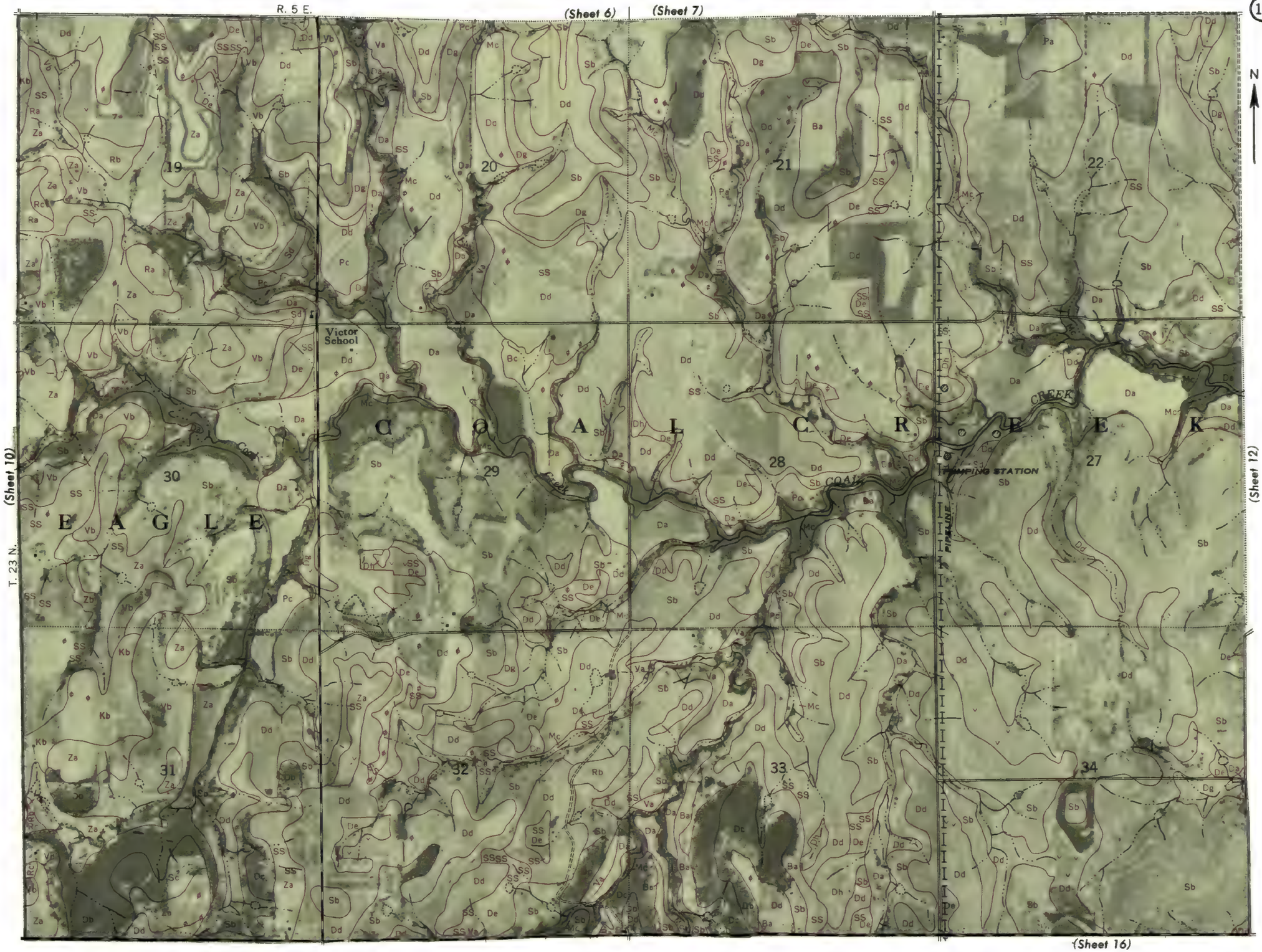

10
(Sheet 5)
(Sheet 6)
R. 4 E.
N
T. 23 N
(Sheet 9)
(Sheet 11)
(Sheet 15)
Highland School
Masham P. O.
MASHAM CEMETERY
PIPELINE
Walker
Creek
Mud Creek
E A G L E
21
22
23
24
25
26
27
28
33
34
35
36
0
1/2
1 Mile
Scale 1:20000
0
5000 Feet



0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

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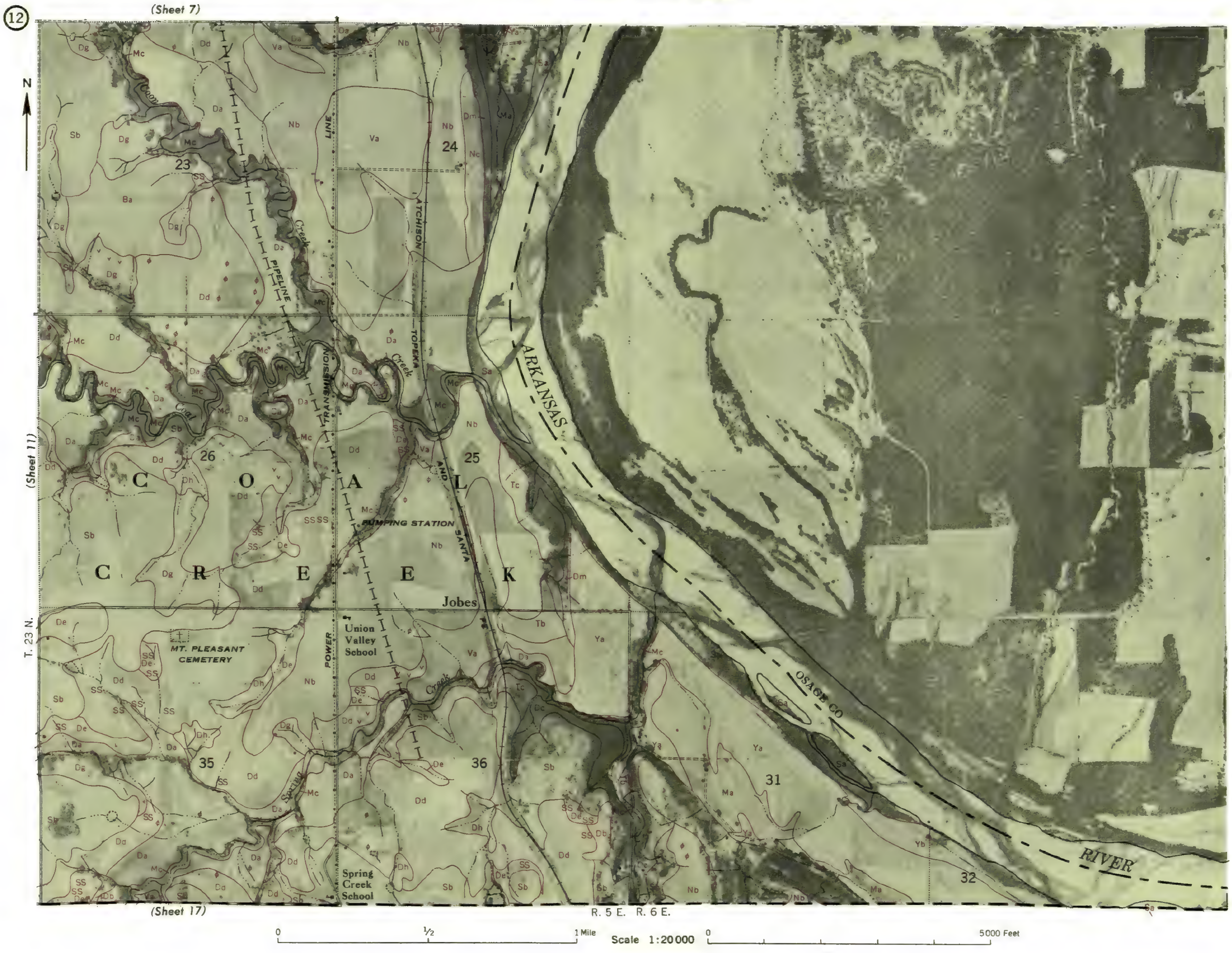
12
(Sheet 7)
N
(Sheet 11)
T. 23 N.
(Sheet 17)
R. 5 E. R. 6 E.
C O A L
C R E E K
Jobes
Union Valley School
MT. PLEASANT CEMETERY
Spring Creek School
PUMPING STATION
ARKANSAS
RIVER
OSAGE CO
ATCHISON TOPEKA AND SANTA FE
TRANSMISSION LINE
PIPELINE
POWER
Coal Creek
Spring Creek
23
24
25
26
31
32
35
36
0
½
1 Mile
Scale 1:20000
0
5000 Feet

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PAWNEE COUNTY, OKLAHOMA

R. 3 E. R. 4 E.

(Sheet 9)

Laird School

N

(Sheet 13)

(Sheet 15)

T. 22 N.

O T O E

P A W N E E

Blue Valley School

(Sheet 21)

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

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16
(Sheet 11)
R. 5 E.
N
T. 22 N.
(Sheet 15)
(Sheet 23)
Hopewell School
PAWNEE
SKEDEE
PIPELINE
Creek
6
5
4
3
8
9
10
18
17
16
15
0
1/2
1 Mile
Scale 1:20000
0
5000 Feet

PAWNEE COUNTY, OKLAHOMA

R. 5 E. | R. 6 E.

T. 22 N.

(Sheet 16)

(Sheet 18)

(Sheet 24)

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet

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(18)

(Inset on Sheet 19)

N

T. 22 N.

(Sheet 17)

Osage School

ARKANSAS

OSAGE CO

RIVER

BLACK BEAR CREEK

SKEDEE

BLACKBURN

TRANSMISSION LINE

POWER

4 3 2 1

9 10 11 12

16 15 14 13

18

(Sheet 25)

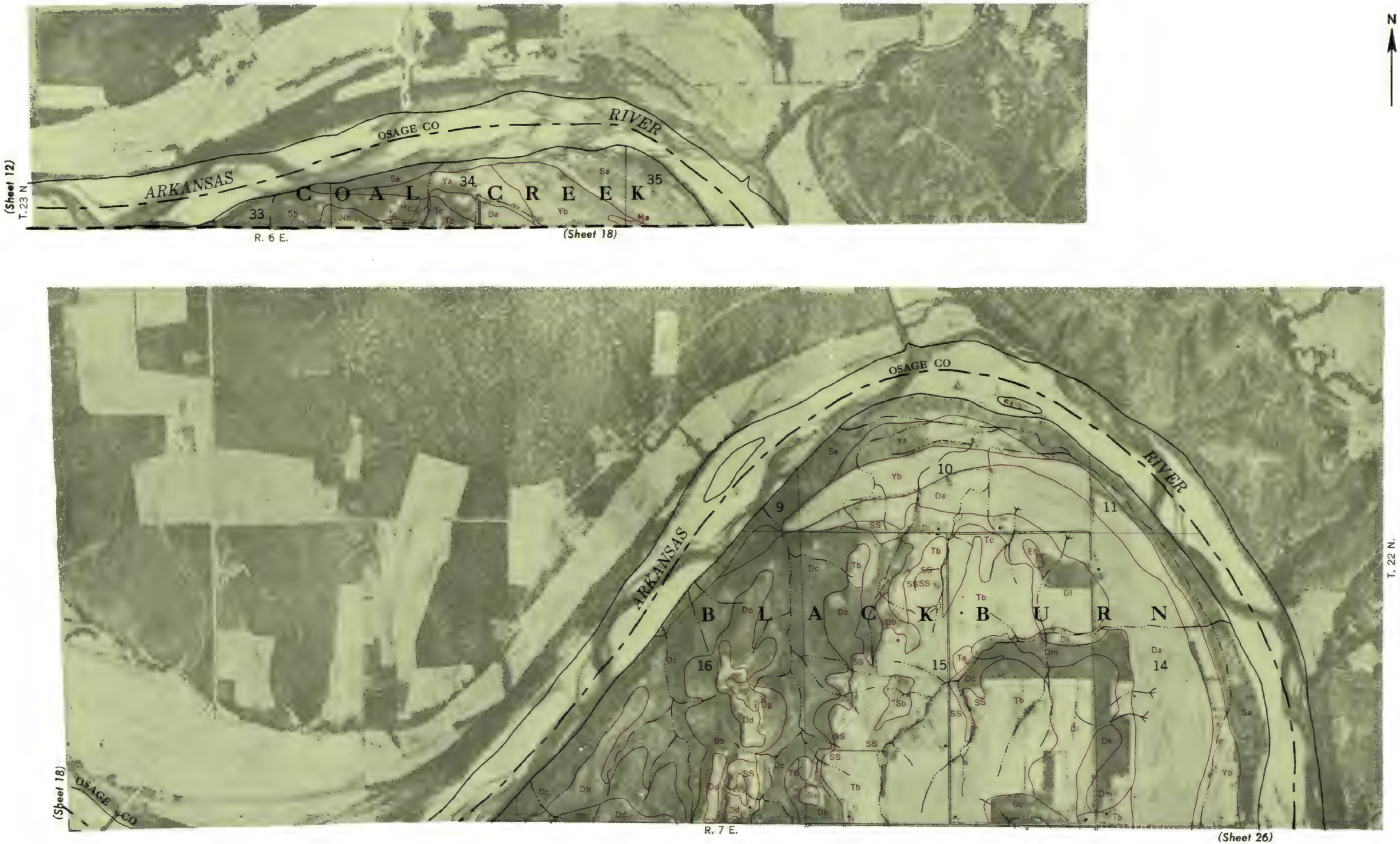
R. 6 E. | R. 7 E.

(Sheet 26)

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet



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PAWNEE COUNTY, OKLAHOMA

(Sheet 13)

R. 3 E.

20

N

NOBLE CO

19 20 21 22

30 29 28 27

31 32 33 34

T. 22 N.

(Sheet 21)

NOBLE CO

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet

PAWNEE COUNTY, OKLAHOMA

R. 3 E. R. 4 E.

(Sheet 14)

21

N

(Sheet 20)

(Sheet 22)

T. 22 N.

NOBLE CO

(Sheet 27)

Scale 1:20000

0 ½ 1 Mile

0 5000 Feet

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22
(Sheet 15)
R. 4 E.
N
(Sheet 21)
(Sheet 23)
(Sheet 28)
T. 22 N
P A W N E E
21
22
23
24
25
26
27
28
33
34
35
36
BLACK BEAR CREEK
Peters Creek
ST LOUIS SAN FRANCISCO
0 1/2 1 Mile
Scale 1:20 000
0 5000 Feet

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R. 5 E.

(Sheet 16)

N

(Sheet 22)

(Sheet 24)

T. 22 N.

(Sheet 29)

PAWNEE RESERVOIR

INDIAN CEMETERY

PAWNEE CEMETERY

PIPELINE

Skedee Creek

PAWNEE CO. FAIRGROUNDS

BLACK BEAR CREEK

SANTA FE

ATCHISON, TOPEKA AND SAN FRANCISCO ST. LOUIS

COURTHOUSE

Pawnee Agency and Indian School

PAWNEE

19 20 21 22 27 28 29 30 31 32 33 34

Scale 1:20000

0 ½ 1 Mile

0 5000 Feet

(24)

(Sheet 17)

R. 5 E. | R. 6 E.

N

Buena Vista School

SKEDEE CEMETERY

TRANS POWER LINE

SANTA FE PIPELINE

Esau Junction

AND

TOPEKA

ATCHISON

BLACK BEAR CREEK

POWER

TRANS LINE

23 24 19 20 26 25 30 29 35 36 31 32

S K E D E

(Sheet 23)

(Sheet 25)

T. 22 N.

(Sheet 30)

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

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PAWNEE COUNTY, OKLAHOMA

(Sheet 18) | (Sheet 19)

R. 7 E.

N

T. 22 N.

(Sheet 25)

(Sheet 32)

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet

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PAWNEE COUNTY, OKLAHOMA

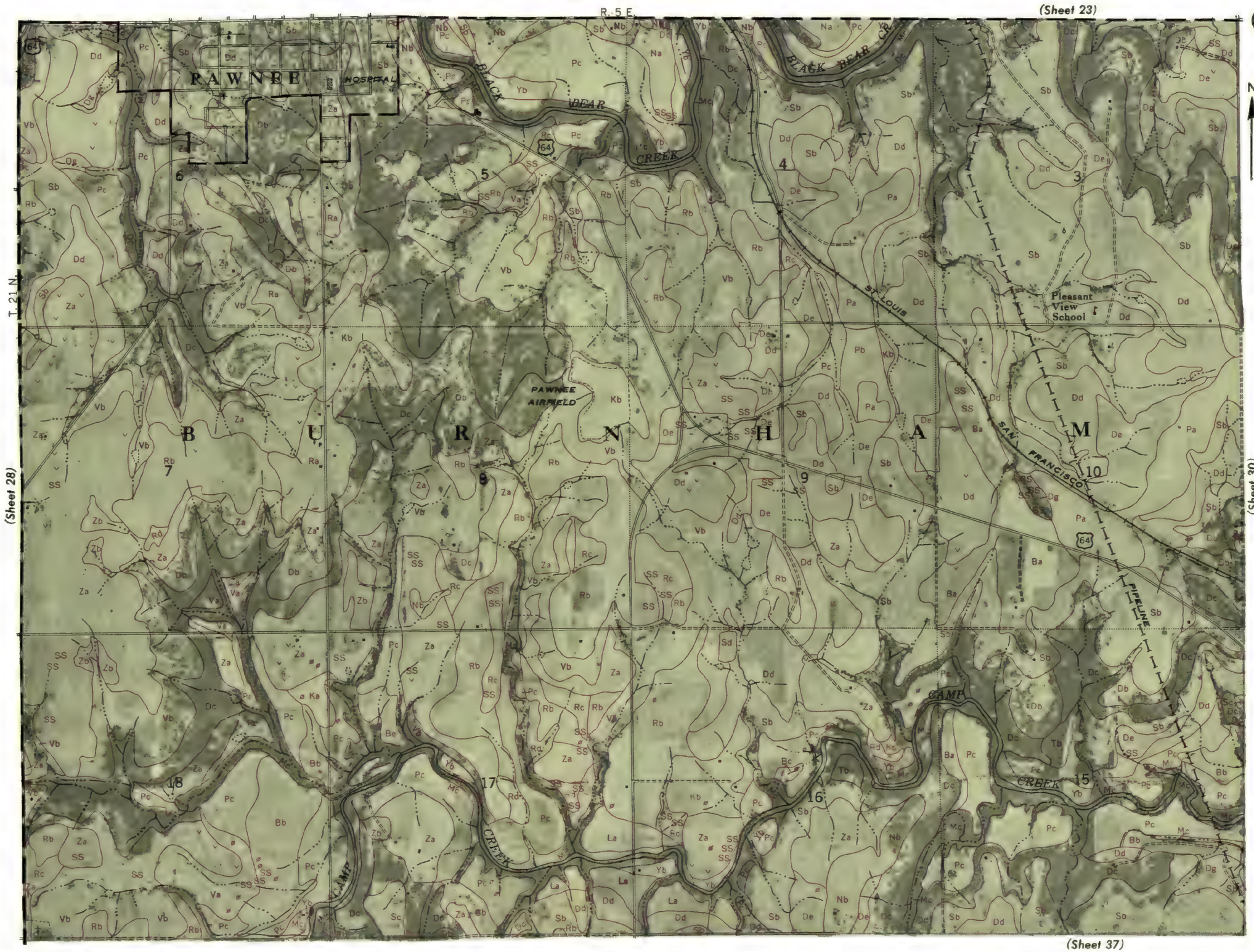
0 ½ 1 Mile

Scale 1:20000

0 5000 Feet

28
(Sheet 22)
R. 4 E.
N
(Sheet 27)
(Sheet 29)
(Sheet 36)
T. 21 N.
ST LOUIS
SAN FRANCISCO
AT & SF
SANTA FE
Olive Hill School
L I B E R T Y
ATCHISON
TOPEKA
Pepper Creek
Black Bear Creek
64
1
2
3
4
9
10
11
12
13
14
15
16
0
1/2
1 Mile
Scale 1:20000
0
5000 Feet

PAWNEE COUNTY OKLAHOMA



0 ½ 1 Mile Scale 1:20000 0 5000 Feet

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(Sheet 24)

R. 5 E. R. 6 E.

T. 21 N.

(Sheet 29)

(Sheet 31)

(Sheet 38)

BURNHAM VALLEY

Cody

Union Star School

BLACK BEAR CREEK

CAMP CREEK

SANTA FE

TOPEKA AND

ATCHISON

AT & SF

PIPELINE

TRANS POWER LINE

ST. LOUIS SAN FRANCISCO

64

1 2 5 6 7 8 11 12 13 14 17 18

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

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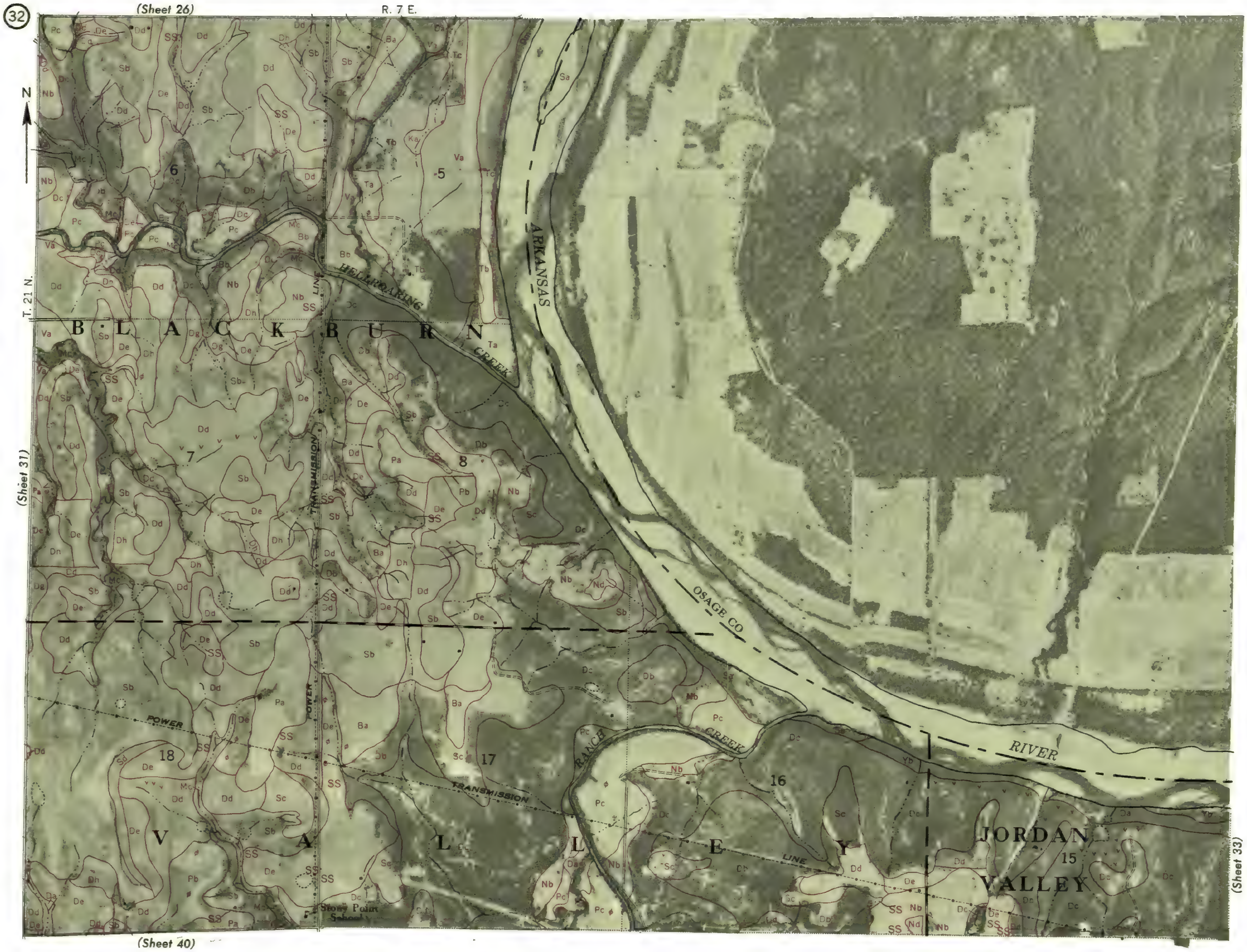

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

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34
N
T. 21 N.
(Sheet 33)
(Sheet 42)
R. 8 E.
CLEVELAND
JORDAN VALLEY
ARKANSAS
OSAGE CO
RIVER
POWER TRANS LINE
MISSOURI
KANSAS
TEXAS
CEDAR CREEK
PIPELINE
64
4
10
15
16
Da
Sa
Ya
Yb
Ma
Mc
Ta
Tb
Tc
Ca
Dc
Db
SS
SSSS
0
½
1 Mile
Scale 1:20000
0
5000 Feet

PAWNEE COUNTY, OKLAHOMA

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

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PAWNEE COUNTY, OKLAHOMA

R. 4 E.

(36)

(Sheet 28)

N

Duff School

SANTA FE AND TOPEKA ALCHISON

21 22 23 24

28 27 26 25

33 34 35 36

L I B E R T Y

Camp Creek

(Sheet 35)

(Sheet 37)

T. 21 N.

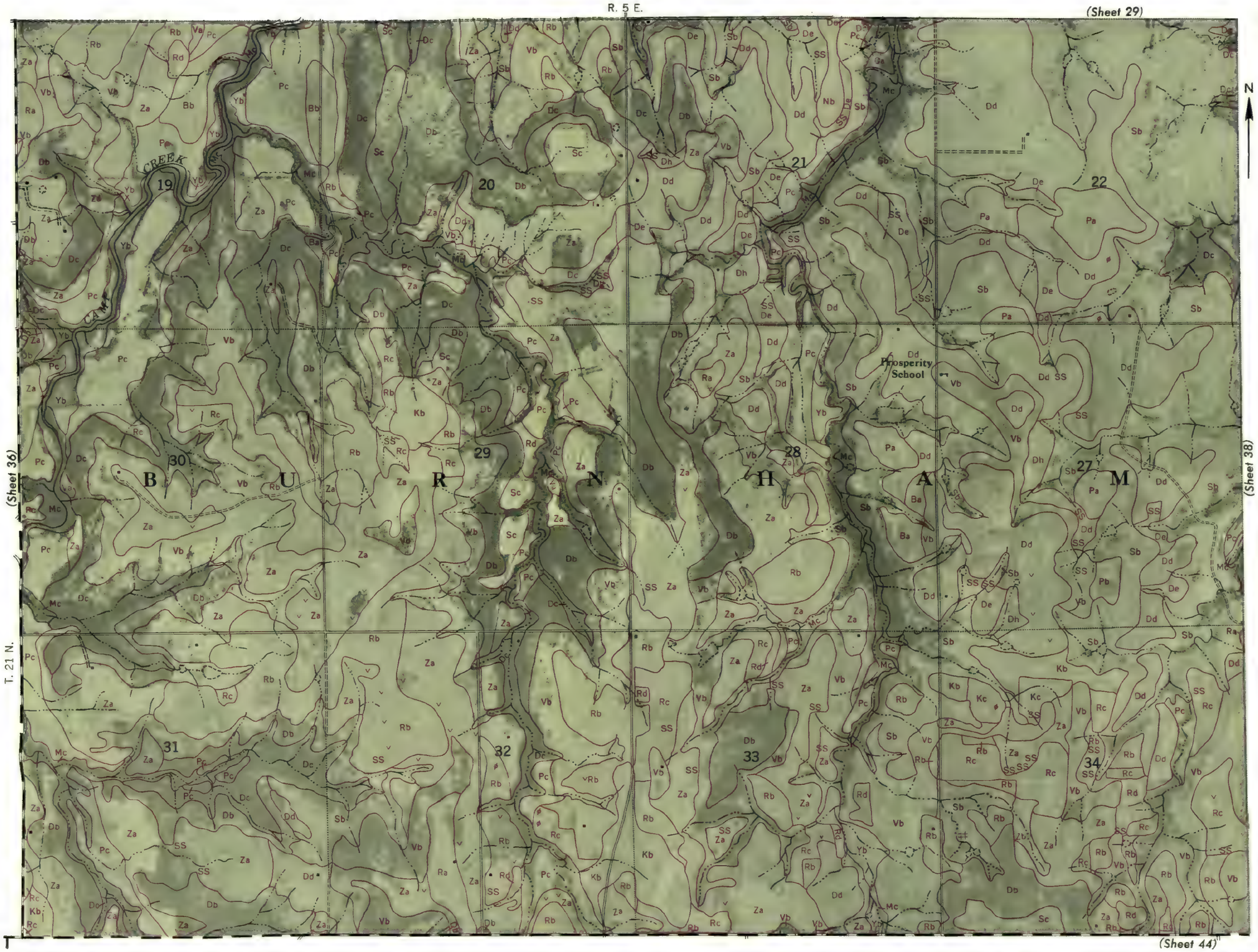
PAYNE CO

PAYNE CO

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet



0 ½ 1 Mile Scale 1:20000 0 5000 Feet

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PAWNEE COUNTY, OKLAHOMA

R. 5 E. R. 6 E.

38

(Sheet 30)

N

(Sheet 37)

(Sheet 39)

T. 21 N.

B U R N H A M

V A L L E Y

ATCHISON, TOPEKA AND SANTA FE

ST. LOUIS SAN FRANCISCO

PIPELINE

PIPELINE

64

64

23 24 19 20

26 25 30 29

35 36 31 32

Maramec Lake

(Sheet 45)

(Sheet 46)

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet

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PAWNEE COUNTY, OKLAHOMA

R. 7 E.

40

(Sheet 32)

N

(Sheet 39)

(Sheet 41)

T. 21 N.

(Sheet 47) (Sheet 48)

CLEVELAND RESERVOIR

RANCH CREEK

Turkey Creek

POWER TRANSMISSION LINE

High Grove School

JORDAN VALLEY

ST LOUIS

SAN FRANCISCO

TEXAS

KANSAS

MISSOURI

Greenup

19 20 21 22 27 28 29 30 31 32 33 34

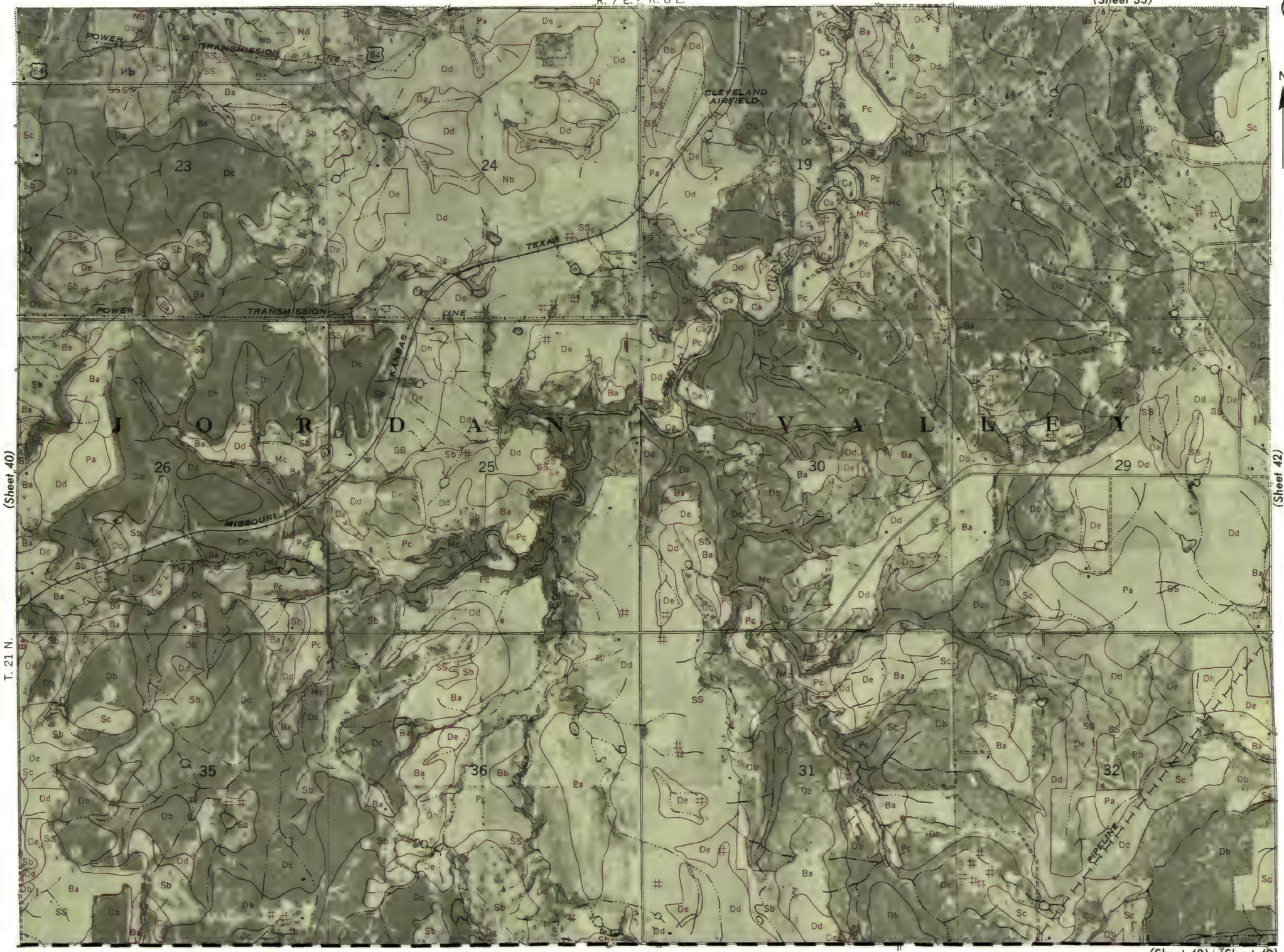
0 ½ 1 Mile

Scale 1:20 000

0 5000 Feet

R. 7 E. | R. 8 E.

(Sheet 33)



(Sheet 40)

(Sheet 42)

(Sheet 48) | (Sheet 49)

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet

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PAWNEE COUNTY, OKLAHOMA

(Sheet 34)

R 8 E

N

SQUIRREL KANSAS TEXAS

ARKANSAS RIVER

OSAGE CO

TRANSMISSION LINE

POWER PIPELINE

PIPELINE

PIPELINE

PIPELINE

PIPELINE

21 22 28 27 26 25 33 34 35 36

J O R D A N V A L L E Y

(Sheet 41)

(Sheet 43)

T. 21 N.

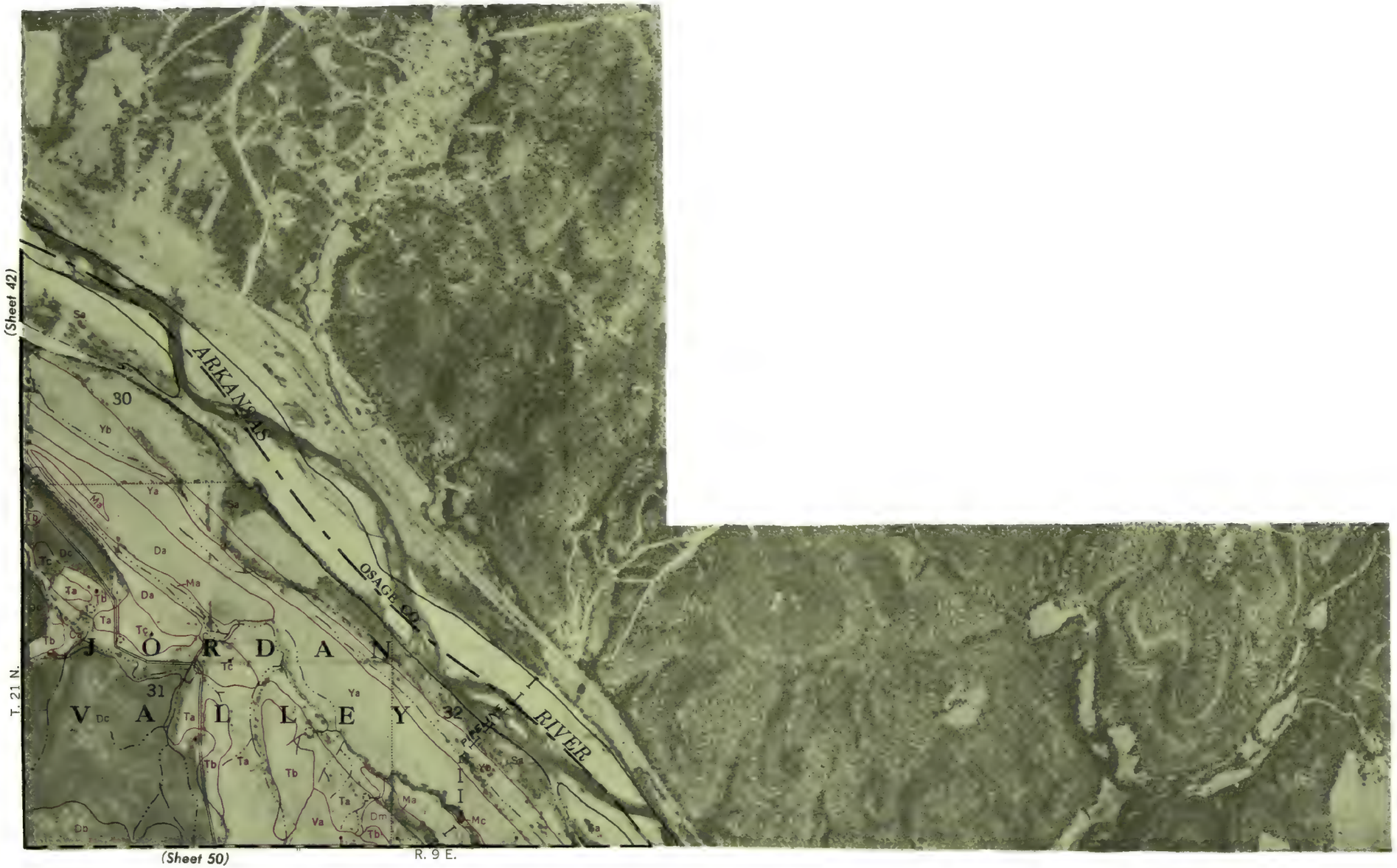
(Sheet 49) (Sheet 50)

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet

N



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(Sheet 37)

R. 5 E.

(Sheet 37)

N

Done Chimney School

T. 20 N.

(Sheet 45)

BANNER

PAYNE CO

(Sheet 52)

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet

PAWNEE COUNTY, OKLAHOMA

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

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PAWNEE COUNTY, OKLAHOMA

(46) (Sheet 38) (Sheet 38)

R. 6 E

N

Maramec

Silver Creek School

Ranch

T. 20 N.

LAGOON

(Sheet 45)

(Sheet 47)

(Sheet 54)

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet

PAWNEE COUNTY, OKLAHOMA

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(Sh 40) | (Sheet 41)

R. 7 E. | R. 8 E.

N

(Sheet 47)

(Sheet 49)

T. 20 N.

MCELROY

HOUSE CREEK

PIPELINE

Greenwood School

(Sheet 56)

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet

PAWNEE COUNTY, OKLAHOMA

R. 8 E.

(Sheet 41) (Sheet 42)

(Sheet 48)

(Sheet 50)

(Sheet 57)

T. 20 N.

49

N

HOUSE CREEK

PIPELINE

BEAR CREEK CEMETERY

Bear Creek

Grandview School

Cowskin Creek

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet

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PAWNEE COUNTY, OKLAHOMA

R. 9 E.

50

(Sheet 42) (Sheet 43)

N

ARKANSAS RIVER

OSAGE CO

DIXIE CEMETERY

BEAR CREEK

PIPELINE

CIMARRON

T. 20 N.

Rigsby School

(Sheet 49)

(Sheet 51)

(Sheet 58)

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet

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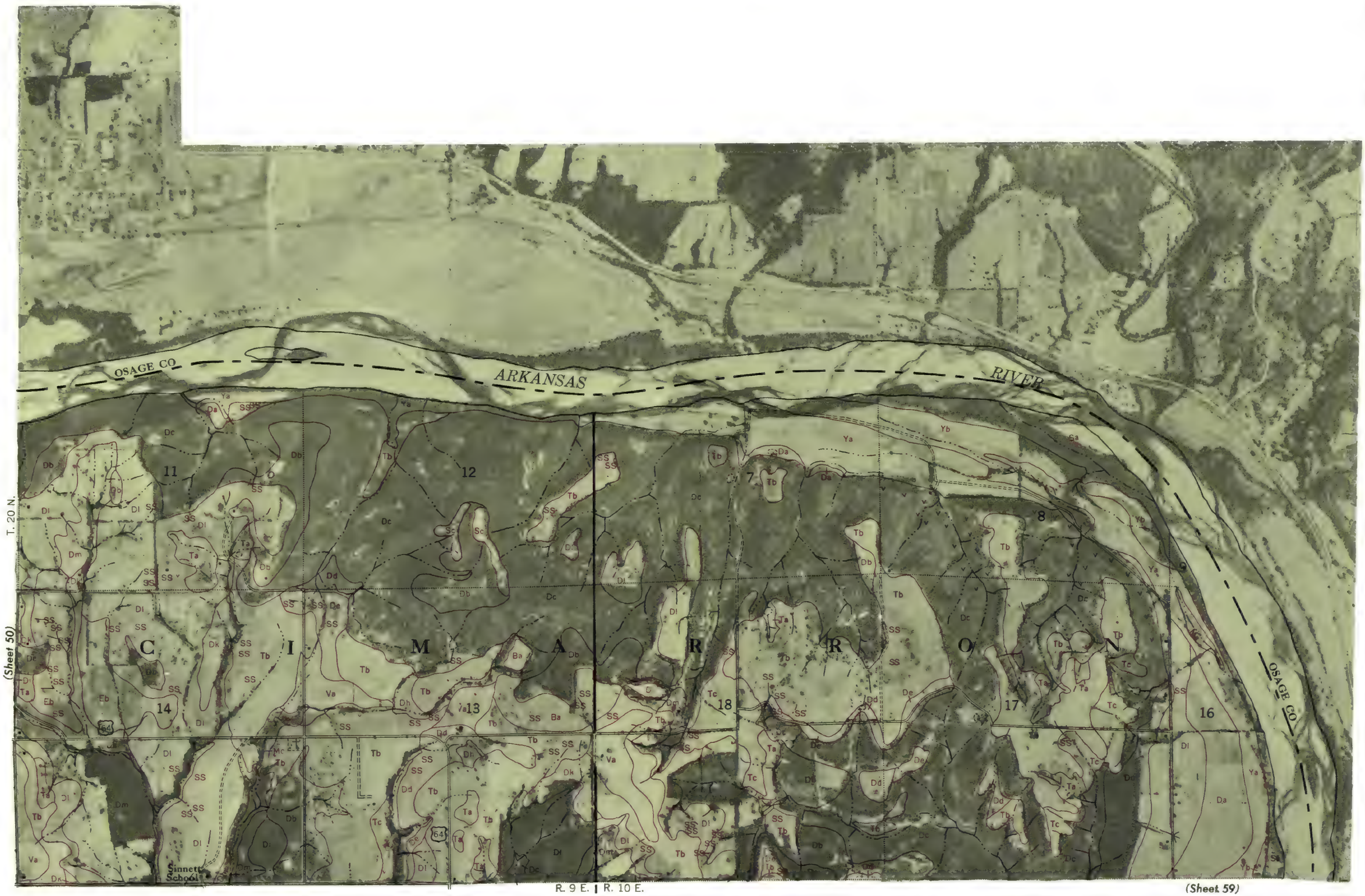


PAWNEE COUNTY, OKLAHOMA

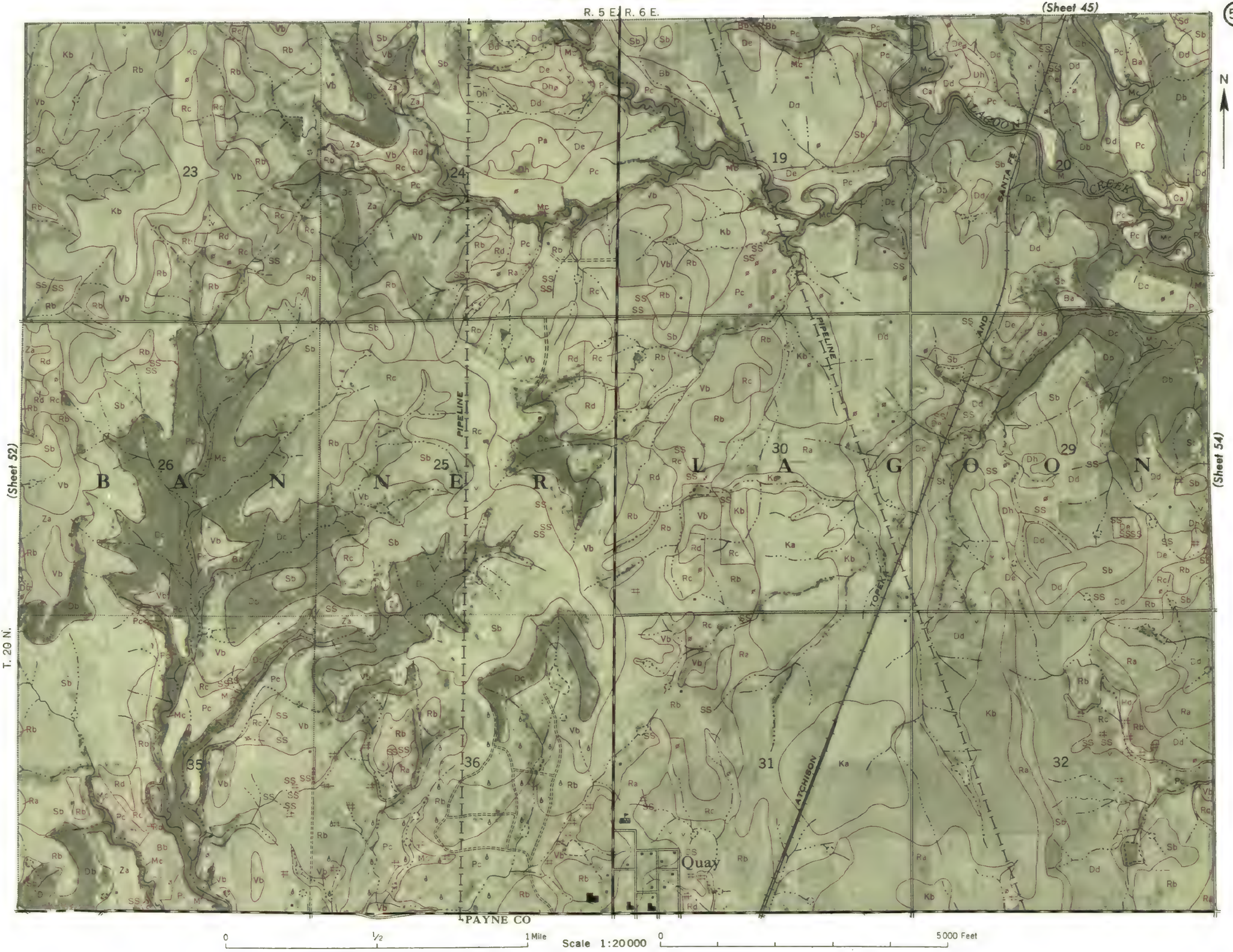
(Sheet 44)

R. 5 E.

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet



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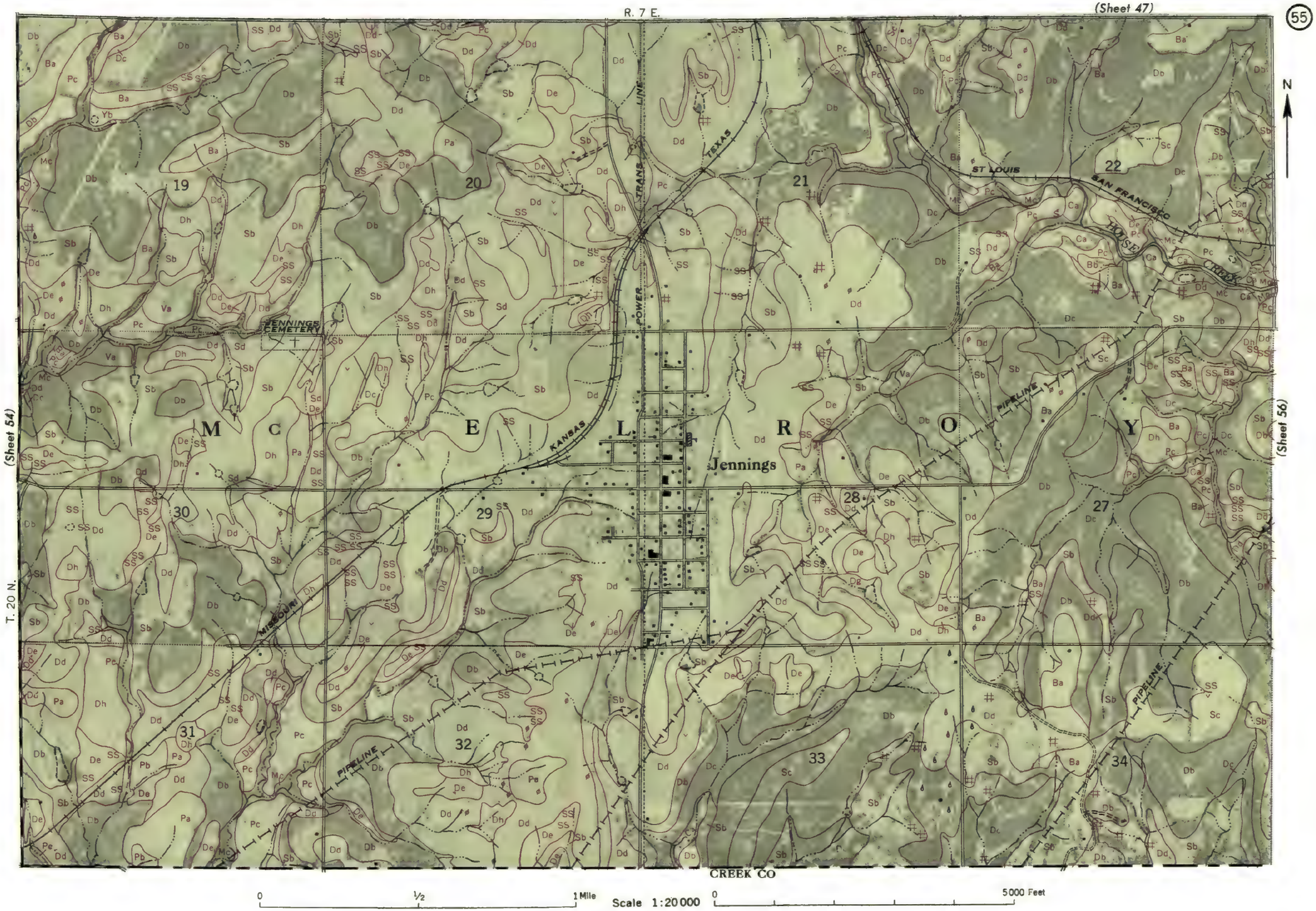
54
(Sheet 46)
R. 6 E.
(Sheet 55) | (47)
N
(Sheet 53)
T. 20 N.
21
22
23
24
25
26
27
28
33
34
35
36
L A G O O N
Bethel School
LAGOON CREEK
MISSOURI
KANSAS
TEXAS
CREEK CO
PAYNE CO
0
1/2
1 Mile
Scale 1:20 000
0
5000 Feet



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56
(Sheet 48)
R. 7 E
R. 8 E.
N
(Sheet 55)
(Sheet 57)
T. 20 N.
TERLTON CEMETERY
PIPELINE
ST LOUIS
SAN FRANCISCO
HOUSE
CREEK
Terlton
M C E L R O Y
H O U S E
C R E E K
23
24
19
20
26
25
30
29
35
36
31
32
CREEK CO
0
1/2
1 Mile
Scale 1:20000
0
5000 Feet

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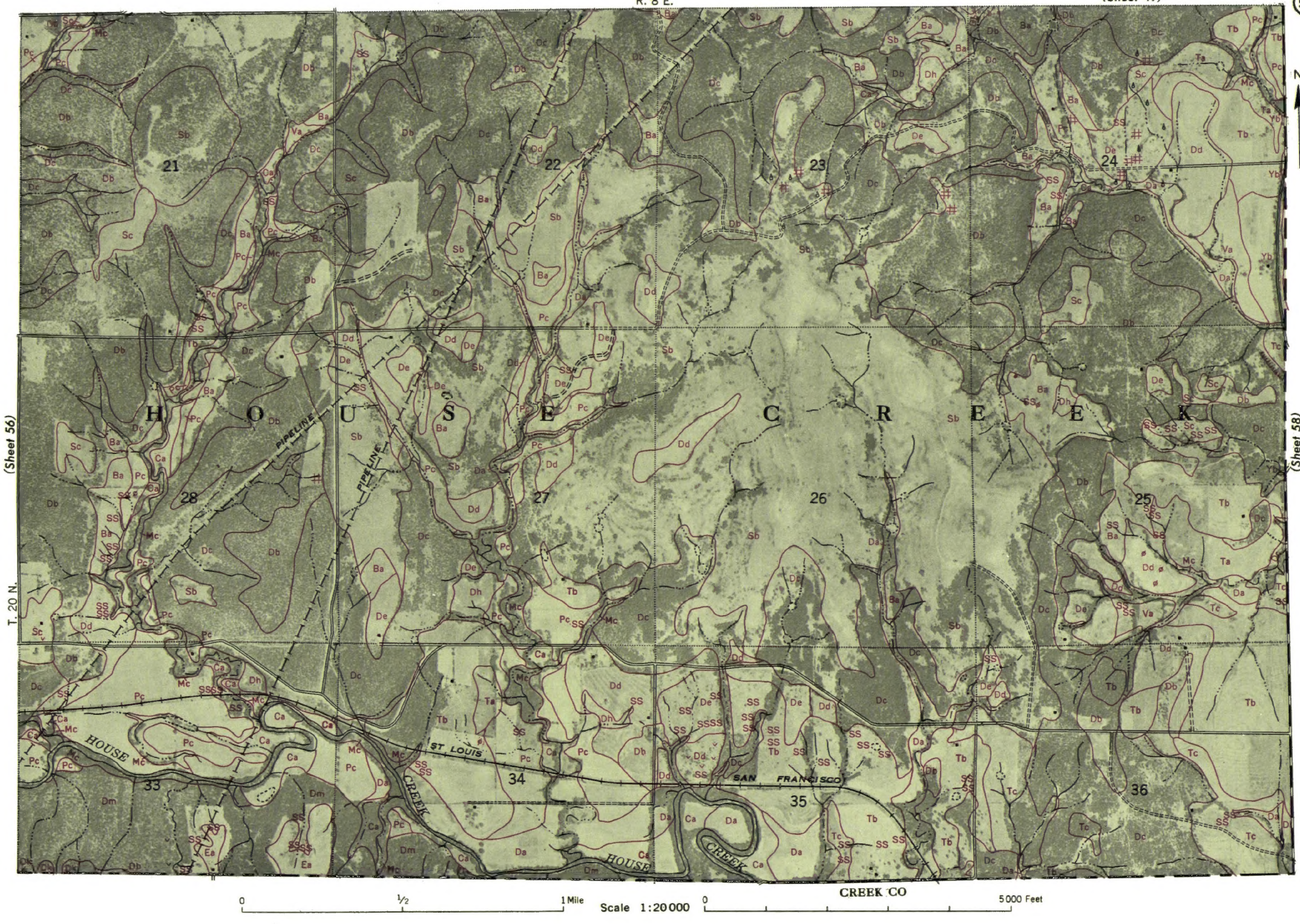


(Sheet 50)

N

CIMARRON RIVER

19 20 21 22

C I M A R R O N

30 29 28 27

31 32 33 34

CIMARRON RIVER

(Sheet 57)

(Sheet 59)

T. 20 N.

CREEK CO

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet

R. 9 E. | R. 10 E.

(Sheet 51)

(Sheet 58)

T. 20 N.

N

CIMARRON RIVER

ARKANSAS RIVER

OSAGE CO

CREEK CO | TULSA CO

Keystone Pond

Keystone

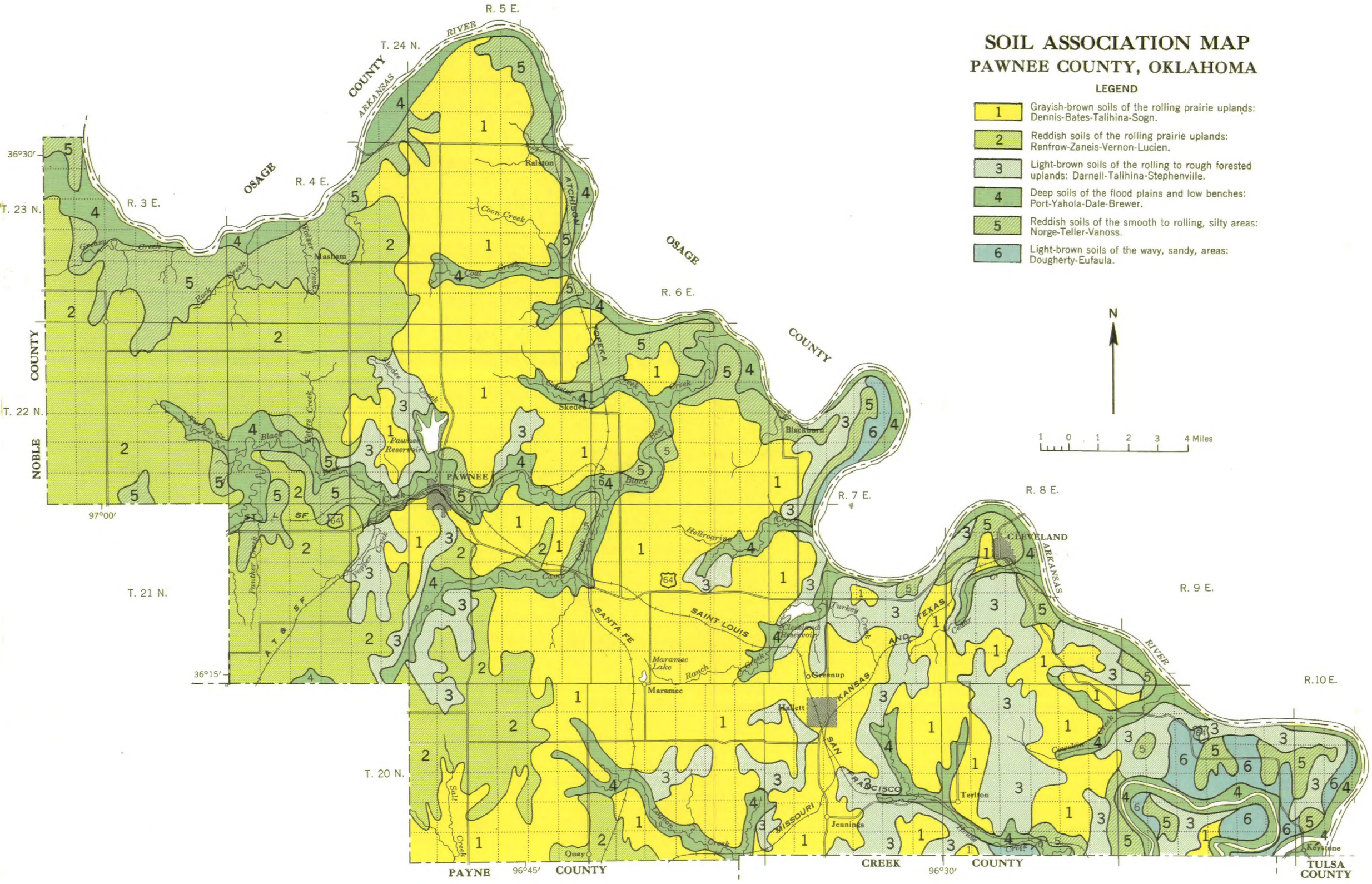
ST L & SF

23 24 25 26 19 20 21 29 30 35 36 31

0 ½ 1 Mile

Scale 1:20000

0 5000 Feet


SOIL ASSOCIATION MAP
PAWNEE COUNTY, OKLAHOMA
LEGEND
1 Grayish-brown soils of the rolling prairie uplands: Dennis-Bates-Talihina-Sogn.
2 Reddish soils of the rolling prairie uplands: Renfrow-Zaneis-Vernon-Lucien.
3 Light-brown soils of the rolling to rough forested uplands: Darnell-Talihina-Stephenville.
4 Deep soils of the flood plains and low benches: Port-Yahola-Dale-Brewer.
5 Reddish soils of the smooth to rolling, silty areas: Norge-Teller-Vanoss.
6 Light-brown soils of the wavy, sandy, areas: Dougherty-Eufaula.
N
1 0 1 2 3 4 Miles
R. 5 E.
R. 4 E.
R. 3 E.
R. 6 E.
R. 7 E.
R. 8 E.
R. 9 E.
R. 10 E.
T. 24 N.
T. 23 N.
T. 22 N.
T. 21 N.
T. 20 N.
36°30′
36°15′
97°00′
96°45′
96°30′
OSAGE COUNTY
NOBLE COUNTY
PAYNE COUNTY
CREEK COUNTY
TULSA COUNTY
ARKANSAS RIVER
PAWNEE
Ralston
Masham
Skedee
Blackburn
Pawnee Reservoir
Maramec Lake
Maramec
Greenup
Hallett
Jennings
Terlton
Quay
Keystone
CLEVELAND
Cleveland Reservoir
ATCHISON TOPEKA AND SANTA FE
SAINT LOUIS AND SAN FRANCISCO
KANSAS AND TEXAS
MISSOURI
Coon Creek
Coat Creek
Black Bear Creek
Hellroaring Creek
Turkey Creek
Cedar Creek
Salt Creek
Lagoon Creek
Panther Creek
Pepper Creek
Walker Creek
Rock Creek
Greasy Creek
Cowskin Creek
Camp Creek
Ranch Creek
Bear Creek
Skedee Creek
Turkey Cr.
Black Creek
Peters Creek
Cedar Cr.
Hoose Creek
64